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with highest respect of
the author.

EXPERIMENTAL RESEARCHES.

EXPERIMENTAL RESEARCHES

RELATIVE TO THE

NUTRITIVE VALUE AND PHYSIOLOGICAL EFFECTS

OF

ALBUMEN, STARCH, AND GUM,

WHEN

SINGLY AND EXCLUSIVELY USED AS FOOD.

BEING THE

PRIZE ESSAY OF THE AMERICAN MEDICAL ASSOCIATION FOR 1857.

BY

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Quem sequimur? quove ire jubes? ubi ponere sedes?
Da pater augurium, atque animis illabere nostris!

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EXPERIMENTAL RESEARCHES.

INTRODUCTION.

From the first moment of existence to its termination, two processes are constantly progressing in the healthy organic being. The first of these, Nutrition, is that by which the several tissues of the body are primarily formed, and subsequently developed and nourished; the second, Decay, is the direct antagonist of the former, and through it, those portions of the organism which have performed the office in the economy for which they were assimilated, are decomposed into simpler substances, and after undergoing continued metamorphosis, are eventually excreted from the system. The continuation of these forces constitutes life, the cessation of either of them, for even a limited period, induces death.

The present memoir embraces the consideration of these actions, as they occur in the human system, under certain fixed conditions of alimentation, and is especially intended to show by actual experiments, in what manner they are affected by albumen, starch, and gum, when singly and exclusively used as food.

It does not comport with the character of this essay to enter into an elaborate detail of the ordinary course and phenomena of nutrition, or of the destructive metamorphosis of the animal tissues, neither would this be necessary, for, the works of Liebig, Carpenter, and Draper, and the erudite and philosophical treatise of Lehmann, are so readily accessible to the profession, as to render such a procedure a work of supererogation; yet, a few words in relation to some of the principal points connected with them, may not be altogether out of place, and with a statement of the scope of the present investigations, and of the methods employed in the necessary analyses, may serve as an introduction to the more immediate subjects of experiment.

The food which is required by man to maintain a proper degree of activity in the several functional actions of the system, and to repair the waste in the tissues induced by them, may be divided into four classes.

1st. The protein-compounds; albumen, fibrin, casein, gluten, &c., whose most important element is nitrogen, and whose office in the organism is particularly of a histogenetic character.

2d. The fats; which serve for the maintenance of the animal heat by undergoing oxidation into carbonic acid, and water, enter into the composition of the primary cells of the tissues, and are probably, active agents in the solution and metamorphosis of the nitrogenous articles of food.

3d. The carbo-hydrates; starch, sugar, gum, &c., some of which, like the fats, serve to support the heat of the body, and which, within the system, may undergo transformation into them.

4th. Inorganic substances; under which head are included water, and certain minerals which enter essentially into the composition of the blood and tissues.

Besides the above, various other substances, such as alcoholic liquors, coffee, tea, spices, &c., are frequently taken into the stomach with the food, strictly so called, which, though not contributing directly to the nutrition of the body, are yet often serviceable in promoting digestion, and restraining the too rapid waste of the animal tissues.

Though albumen (the type of the protein-compounds) contains carbon, hydrogen, and oxygen, in addition to nitrogen, and is, therefore, *par excellence*, the tissue-forming material, it has been determined by experiments upon the inferior animals, that a sufficiency of such food to sustain vitality for any length of time, cannot be assimilated by the digestive organs; and that, unless fat, starch, or some other of the respiratory aliments, together with a proper amount of inorganic salts, be also ingested, the animal soon perishes with all the symptoms of starvation.

In order, therefore, to keep the vital functions at their maximum healthy standard of action, it is essential that the food should be so adjusted in quantity and quality, as to subserve all the purposes of plastic formations, and, at the same time, maintain the calorific process at its due degree of activity.

Though instinct and experience are generally sufficient to make such an arrangement of aliments as is adequate to fulfil the ordinary requirements of the system, yet, observation is constantly

teaching us, that these guides are not of themselves always correct in their indications, and that disease, and even death, are frequently induced from the want of a more enlightened system of dietetics.

An extensive series of observations is necessary, before we can arrange such a system; before we can so proportion the different classes of food to the individual as to be able to determine, *a priori*, how much of each should be ingested under certain defined conditions and circumstances. Such investigations should especially embrace the determination of the quantities and qualities of the egesta under definite conditions of food, mental and physical exercise, sleep, &c.; repeated analyses of the blood should be made, and at the same time, note taken of all the physical, physiological, and pathological circumstances, capable of influencing the results. In addition to the correct ideas of nutrition, and the other physiological processes, which researches of this nature carried on for a long period would give us, we should also be far advanced towards the attainment of that exactness in medical science, to which all our efforts should be directed.

The theory at present received, explanatory of the process by which the disintegration and metamorphosis of the animal substance occurs, may be briefly stated as follows:—

No part or organ of the body can exercise its functions without a certain portion of the tissue entering into its composition losing its vitality. Interstitial death is thus coeval and coexistent with life.

The bodily material which has become devitalized, re-enters the circulation, and mingles with the general mass of the blood. "No organized substance, no part of any plant or animal, after the extinction of the vital principle, is capable of resisting the chemical action of air and moisture."[1] The effete tissue meets in the blood-vessels with both oxygen and water, and also with a temperature which experiment has demonstrated to be that at which decomposition most readily takes place. Under the combined influence of these agents, the worn-out material is resolved into less complex substances, and is at length, under new forms, eliminated from the system.

Four great channels serve to rid the organism of the products resulting from the decay of its component parts; the lungs, through which carbonic acid, water, and a small portion of nitrogen escape;

[1] Liebig's Letters on Chemistry, London ed., p. 211.

the skin, eliminating principally water, with some carbonic acid, and salts; the intestines, through which (in addition to the unassimilated residue of the food) decomposed bile, gases, &c., are excreted; and the kidneys, giving exit to water, salts, and especially nitrogenous substances.

As previously remarked, in order to exhibit fully the extent of the nutritious and regressive metamorphosis of tissue in a definite time, and under certain conditions, the ingesta and excreta of the same period should be carefully measured, and the nature and quantities of their several constituents exactly determined. In addition, the weight of the body should be accurately taken at stated intervals during the continuance of the investigations, and observations frequently made of the density, moisture, and temperature of the atmosphere.

The ensuing researches, though conducted generally on this plan, are yet far from being perfect, and can only be regarded as affording approximative results. In the present state of our knowledge, the difficulty, if not impossibility, of estimating accurately the total amount of oxygen abstracted from the inspired air, and retained in the system, and the loss from the lungs, and the skin separately, is a bar to precise investigation. Nevertheless, I am sensible that the experiments detailed in this memoir will prove valuable as contributing to a fuller understanding of the effects upon the human system of the different articles of food used, and as indicating the value of these substances as aliments.

The investigations were all instituted upon myself. During their continuance, no other food than that experimented with was taken into the system. An interval sufficient to restore the organism to its normal condition was suffered to elapse after each series, before the following one was commenced. During this interval, I lived upon a full and nutritious diet, and endeavored so to arrange the ingesta as to supply the economy with those substances which it most needed.

My usual manner of living, during each of the succeeding series of experiments, was as follows:—

I arose from bed at 6½ A. M., and retired at 10½ P. M. Eight hours of the twenty-four were accordingly passed in inactivity, the remaining sixteen were apportioned in the following manner. Eight were occupied in conducting the necessary analyses, and in other work of the laboratory; four were given to chemical and physiological studies; and four were taken up with the duties of

my profession, physical exercise, recreation, &c. The exercise was quite limited, consisting of walking about one thousand yards per day. Each period of twenty-four hours is reckoned from 7 A. M. to the same hour the ensuing morning.

The following determinations of the egesta were made for each period of twenty-four hours as above defined:—

I. The quantity of urine.
  A. Water.
  B. Solids.
    a. Urea.
    b. Uric acid.
    c. Chlorine.
    d. Sulphuric acid.
    e. Phosphoric acid.
    f. Residue of solid matter.

II. The quantity of feces.
  A. Water.
  B. Solids.
    a. Ether extract.
    b. Alcohol extract.
    c. Water extract.
    d. Insoluble residue.

III. The amount of cutaneous and pulmonary transpirations (calculated).

Besides these observations on the egesta, the weight of the body was ascertained at the close of each period. Observations were also made of the state of the pulse, and the temperature of the body, three times during the day. The latter was always determined in a room, the temperature of which was 60° F., by placing a delicate thermometer under the tongue.

The height of the barometer and thermometer (mean of three observations) is also given for each day.

On the first and last day of each series of researches, an analysis of the blood was made.

In addition to the above, microscopical and chemical examinations of the saliva, urine, and feces, were often made, which are not referred to, unless unusual results were obtained. Thus, the reaction of the saliva was always determined, but is not mentioned, unless it differed from the normal condition by being neutral, or

acid. The reaction of the urine and feces is not stated, unless it was neutral or alkaline—these excretions being usually acid. The urine was also frequently tested for the presence of albumen and sugar, and submitted to microscopical examination. The feces were likewise often examined with the microscope.

In performing the requisite analysis, I made use of the following methods. It will be seen that, wherever it was practicable, the volumetric process was employed. This was done, not only because it yields more accurate results than the method of precipitating and weighing, but also because it is more easy of execution, and requires less time. I have merely indicated the special methods, without going into detailed descriptions of them.[1]

Urine.—The whole quantity of this excretion for the twenty-four hours was accurately weighed.

The water and solids were estimated by evaporating to as perfect dryness as possible, over sulphuric acid, in the vacuum of an air-pump, a weighed portion of the whole quantity of urine passed in twenty-four hours. The loss of weight indicated the amount of water, and the weight of the residue, the quantity of solid matter contained in this portion. By simple calculation, these were found for the total amount of urine evacuated during the day. This process is open to the objection, that it is impracticable by it to deprive the specimen of urine of all its water. The quantity of this latter remaining, when a good vacuum is kept up, is, however, very small, and, upon the whole, the results obtained are more exact than when evaporation by heat is practised, as the decomposition of the urine, which always attends this latter process, is entirely avoided.

The *urea* was determined by a titrited solution of the nitrate of mercury, as originally proposed by Liebig.

The *uric acid*, by precipitation with hydrochloric acid from a known quantity of the urine, and subsequent weighing.

The *chlorine*, by Liebig's method with the nitrate of mercury.

The *sulphuric acid*, by a titrited solution of chloride of barium.

The *phosphoric acid*, by Liebig's process with a titrited solution of perchloride of iron.

[1] For full accounts of all the analytical processes made use of in these experiments, and for much other information valuable to those engaged in physiologico-chemical investigations, the reader is referred to Von Gorup-Besanez' Anleitung zur zoochemischen Analyse, a work which has not yet found its counterpart in the English language.

The *residue of solid matter* was found by deducting the sum of the above constituents from the total amount of solids.

Feces.—The whole quantity of the twenty-four hours was first accurately weighed.

The *water* and *solids* were determined by taking a known weight of the feces (when more than one stool occurred in the twenty-four hours these were previously well mixed), and evaporating it to dryness in a chloride of calcium bath at a temperature of 220° F., till upon repeated trials it ceased to lose weight. The loss showed the proportion of water, and the weight of the dry residue that of the solids in the portion submitted to examination. The amount of each in the whole quantity of feces was then calculated from these data.

The *ether*, *alcohol*, and *water extracts*, were severally determined as follows:—

A weighed quantity of the dry feces, obtained as above described, was, in the first place, exhausted with ether in Von Bibra's apparatus. The residue was then treated with alcohol of .83 specific gravity, till this substance failed to extract anything more. The substance remaining was then submitted to the action of distilled water, till it was thoroughly exhausted. The extracts obtained by these means were then evaporated, dried at the temperature proper for each, weighed, and the quantity of each in the whole amount of dry feces calculated. The sum of the whole quantity of these extracts, deducted from the whole amount of dry feces, gave the insoluble residue.

The amount of loss from the skin and lungs, collectively, was found, when the body lost weight, by adding the amount of loss to the sum of the ingesta, and subtracting from the aggregate the sum of the excretions from the kidneys and intestines. When the body gained weight, the amount of gain was subtracted from the sum of the ingesta, and the sum of the known egesta deducted as before. The result, in either case, was the loss from the skin and lungs.

The weight of the body was determined by a balance capable of turning with the hundredth of a pound, when loaded with 250 pounds.

In the analysis of the blood, I made use of Scherer's method, which embraces the determination of the *water*, *solids*, *albumen*, *extractive*, and *salts* of the *serum separately*, and the *water*, *solids*, *fibrin*, *blood-corpuscles*, *albumen*, *extractive*, *salts*, and *fat*, of the *blood as a whole*. Schcrer's process, though not altogether free from ob-

jection, is pronounced by Professor Lehmann[1] to be the best we at present possess.

The microscope employed in these researches was a very fine one of Powell and Lealand's construction, with object glasses ranging from 1 to $\frac{1}{8}$ inch focal distance.

It is proper that I should state, that I am 28½ years of age, 6 feet 2 inches in height, and measure 38½ inches around the most prominent part of the chest. My weight during the last three years has ranged from 215 to 230 pounds. My habit of body is rather full, temperament sanguineo-nervous. I am of sedentary habits, rarely taking much physical exercise, unless with some specific object in view other than the exercise. I have never indulged freely in alcoholic liquors, and very seldom use them now; tobacco I do not use in any form. For the last three years my health has been excellent. For a year previous to this period, I was troubled with symptoms indicative of disease of the heart, but no organic affection could be discovered on thorough examination, and by care and change of air, I entirely recovered. At the time of commencing these experiments my health was never better.

In order to show the usual condition of my system, and of the several excretions, and thus to afford data on which to base a more correct estimate of the effects of the several articles of food experimented with than could otherwise be formed, I instituted upon myself a preliminary series of investigations, the details of which are here stated.

During this prefatory series of researches, I ate such articles of food as my appetite called for. It was, as I found by experience, almost impossible to measure the quantities of the different alimentary substances ingested, when, as in this instance, no fixed rule of diet was adopted. The liquids, however, were susceptible of easy approximate determination, and the quantities of these are accordingly stated.

The apportionment of the day, as regarded mental and physical exercise, recreation, sleep, &c., was the same as previously stated, and the conditions generally as arranged for the main subjects of inquiry were not materially altered.

In this, and in each of the succeeding series of experiments, all figures expressive of the quantities of the ingesta, egesta, and con-

[1] Physiological Chemistry, vol. i. p. 593 (Am. ed.).

stituents of the latter, refer to Troy grains. The weight of the body is given in pounds and hundredths Avoirdupois.[1]

This series continued five days. As the total weight of the daily ingesta was not determined, no measurement of the loss from the skin and lungs could be made in these investigations.

FIRST DAY.

INGESTA.

Breakfast; hot bread and butter, and beefsteaks. *Luncheon;* cold beef, and bread and butter. *Dinner;* beef soup, roast beef, potatoes, maccaroni, and custard. During the day drank 4420 grains coffee, and 17250 water.

EGESTA.

Kidneys.

Whole quantity of urine 20258.68.

Water	19185.48	
Solids	1073.20	
Urea		628.85
Uric acid		13.27
Chlorine		124.50
Sulphuric acid		45.86
Phosphoric acid		60.13
Residue		210.59

Intestines.

Whole quantity of feces 2310.47.

Water	1702.37	
Solids	608.10	
Ether extract		75.94
Alcohol extract		111.38
Water extract		128.32
Insoluble residue		292.36

My pulse was at 7 A.M. 85 per minute, at 2 P.M. 88, and at 10 P.M. 80.—Mean 84.33.

The temperature of the body at the same hours was respectively 97.5°, 98°, and 98°.—Mean 97.83°.

At 3 P.M. 1525.73 grains of blood were drawn from the median

[1] The pound, Avoirdupois, is equivalent to 7000 grains Troy. The hundredth is consequently 70 grains Troy.

basilic vein. This, upon analysis, was found to be constituted as follows:—

1000 parts of serum—

Water	908.42
Solids	91.58
Albumen	76.18
Extractive	4.27
Soluble salts	10.22
	90.67
Difference	.91

In 1000 parts of serum were contained 11.92 of inorganic salts.

1000 parts of blood—

Water	780.29
Solids	219.71
Fibrin	2.41
Blood corpuscles	143.19
Albumen	65.43
Extractive	4.02
Soluble salts	9.11
	224.16
Difference	4.35

The whole quantity of inorganic salts in 1000 parts of blood was 11.68. In 1000 parts defibrinated blood were 2.24 fat.

The weight of the body at the end of the twenty-four hours was 226.45 pounds. The mean height of the barometer was 29.211 inches, and of the thermometer 43°.

SECOND DAY.

INGESTA.

Breakfast; buckwheat cakes and butter, broiled ham, boiled eggs. *Luncheon;* cold ham and bread and butter. *Dinner;* beef soup, roast beef, potatoes and beets. Drank 5000 grains of coffee, and 18200 water.

EGESTA.

Kidneys.

Whole quantity of urine 22756.37.

Water	21488.15	
Solids	1286.22	
Urea		790.11
Uric acid		10.58
Chlorine		151.28
Sulphuric acid		50.72
Phosphoric acid		66.13
Residue		199.40

Intestines.

Whole quantity of feces 2445.69.

Water	1681.68
Solids	764.01

Ether extract	142.40
Alcohol extract . . .	125.18
Water extract	202.41
Insoluble residue . . .	294.02

At 7 A.M. my pulse was 82, at 2 P.M. 90, and at 10 P.M. 83.—Mean 85.

At the same periods, the temperature of the body was respectively 98°, 98.5°, and 98.5°.—Mean 98.33°.

At the end of the twenty-four hours my weight was 226.52 pounds; showing an increase of .07 pound, or 490 grains.

The mean height of the barometer was 29.341 inches, of the thermometer 46°.

The quantity of food ingested on this day was somewhat greater than usual. Towards evening I had slight headache, which, however, disappeared before bedtime; slept well.

THIRD DAY.

INGESTA.

Breakfast; hot bread and butter, and beefsteak. *Luncheon;* cold ham, and bread and butter. *Dinner;* beef soup, roast chicken, potatoes and cabbage, rice pudding, with wine sauce. Drank in the twenty-four hours 4250 grains of coffee, and 23500 water.

EGESTA.

Kidneys.

Whole quantity of urine 21250.17.

Water	20224.47	
Solids	1025.70	
Urea		620.50
Uric acid		11.57
Chlorine		142.19
Sulphuric acid		35.71
Phosphoric acid . . .		47.31
Residue		168.42

Intestines.

Whole quantity of feces 2041.76.

Water	1537.63	
Solids	504.13	
Ether extract		89.14
Alcohol extract . . .		95.17
Water extract		112.35
Insoluble residue . . .		207.47

The pulse at 7 A. M. was 81, at 2 P. M. 86, and at 10 P. M. 84.—Mean 83.66.

The temperature of the body at the corresponding hours was respectively 98°, 98.5°, and 97.5°.—Mean 98°.

At the end of the day the weight of the body was 226.42 pounds; a loss from the previous day of .10 pound, equivalent to 700 grains.

The mean height of the barometer was 29.241 inches, and of the thermometer 41°.

FOURTH DAY.

INGESTA.

Breakfast; hot bread and butter, and beef hash, highly seasoned. *Luncheon;* cold beef tongue, and bread and butter. *Dinner;* stewed beef, potatoes, maccaroni, and blanc-mange; ate also a supper at 10 P. M. of oysters (preserved in hermetically sealed cans), and bread and butter. Drank in the twenty-four hours 5000 grains of coffee, and 21500 water.

EGESTA.

Kidneys.

Whole quantity of urine 20523.45.

Water	19388.27	
Solids	1134.18	
Urea		710.62
Uric acid		10.91
Chlorine		131.46
Sulphuric acid		44.32
Phosphoric acid		53.87
Residue		183.00

Intestines.

Whole quantity of feces 2204.11.

Water	1472.89	
Solids	731.22	
Ether extract		60.39
Alcohol extract		67.48
Water extract		106.17
Insoluble residue		497.18

At 7 A. M. my pulse was 81, at 2 P. M. 84, and at 10 P. M. 82.—Mean 82.33.

At the same hours the temperature of the body was respectively 97°, 97.5°, and 98°.—Mean 97.50°.

The weight of the body at the end of the twenty-four hours was 226.50 pounds; an increase of .08 pound, equivalent to 560 grains.

The height of the barometer was 28.965 inches, and of the thermometer 40°.

FIFTH DAY.

INGESTA.

Breakfast; hot buckwheat cakes and butter, and beefsteak. *Luncheon;* cold ham, and bread and butter. *Dinner;* beef soup, roast venison, potatoes, cabbage, and maccaroni, preserved citron-melon, and milk. During the day drank 4800 grains of coffee, and 20200 water.

EGESTA.

Kidneys.

Whole quantity of urine 19684.92.

Water	18698.29	
Solids	986.63	
Urea		521.75
Uric acid		12.02
Chlorine		141.26
Sulphuric acid		49.30
Phosphoric acid		51.84
Residue		210.46

Intestines.

Whole quantity of feces 2467.58.

Water	1975.41	
Solids	492.17	
Ether extract		85.14
Alcohol extract		83.60
Water extract		98.52
Insoluble residue		224.91

My pulse at 7 A. M. was 83, at 2 P. M. 88, and at 10 P. M. 85.—Mean 85.33.

The temperature of the body at the same periods was respectively 98°, 98.5°, and 97.5°.—Mean 98°.

At 3 P. M. I abstracted 1293.25 grains of blood from the median

basilic vein, which, upon analysis, was found to possess the following constitution:—

1000 parts of serum—

Water	909.57
Solids	90.43
Albumen . . .	72.21
Extractive . . .	5.32
Soluble salts . .	12.14
	89.67
Difference	.76

The total amount of inorganic salts in 1000 parts of serum was 14.39

1000 parts of blood—

Water	782.46
Solids	217.54
Fibrin	2.36
Blood-corpuscles .	141.25
Albumen . . .	62.10
Extractive . . .	4.25
Soluble salts . . .	11.40
	221.36
Difference . . .	3.82

The total amount of inorganic salts in 1000 parts of blood was 13.75. In 1000 parts of defibrinated blood were 2.78 of fat.

The weight of the body at the close of the twenty-four hours was 226.41 pounds; a loss of .09 pound, or 630 grains.

The mean height of the barometer was 29.042 inches, and of the thermometer 45°.

The following table exhibits the foregoing results in a collected form.

TABLE I.

EGESTA.	1st day.	2d day.	3d day.	4th day.	5th day.	Total.	Mean.
Kidneys—							
Urine	20258.68	22756.37	21250.17	20523.45	19684.92	104493.59	20898.71
Water	19185.48	21485.15	20224.47	19388.27	18698.29	99005.66	19801.13
Solids	1073.20	1268.22	1025.17	1134.18	986.63	5487.93	1097.58
Urea	628.85	790.11	620.50	710.62	521.75	3471.83	694.36
Uric acid . .	13.27	10.55	11.57	10.91	12.02	58.35	11.67
Chlorine . . .	124.50	151.28	142.19	131.46	141.26	690.69	138 13
Sulphuric acid	45.86	50.72	35.71	44.32	49.30	225.91	45.18
Phosphoric acid	60.13	66.13	47.31	53.87	51.84	229.28	55.85
Residue . . .	210.59	199.40	168.42	183.00	210.46	971.87	194.37
Intestines—							
Feces	2310.47	2445.69	2041.76	2204.11	2467.58	11469 61	2293.92
Water	1702.37	1681.68	1537.63	1472.89	1975.41	8369.98	1673.99
Solids	608.10	764.01	504.13	731.22	492.17	3099.63	619.92
Ether extract .	75.94	142.40	89.14	60.39	85.14	453.01	90.60
Alcohol extract	111.38	125.18	95.17	67.48	83.60	482.81	95.56
Water extract .	128.32	202.41	112.35	106.17	98.52	647.77	129.55
Insoluble residue	292.36	294.02	207.47	497.18	224.91	1575.94	303.18
Weight of body . .	226.45	226.52	226.42	226.50	226.41	...	226.46
Pulse	84.33	85.00	83.66	82.83	85.33	...	84.23
Temperature of body	97.83°	98.33°	98°	97.50°	97.50°	...	97.83°
Barometer . . .	...	...	...	...	...	...	...
Thermometer . .	...	...	...	...	...	...	...

I now proceed to consider the main subjects of investigation, regretting, however, that they are not treated in a more complete manner, but indulging the hope, that the time and labor I have bestowed upon them may not prove altogether without profit to physiological science, and that others more learned and with greater facilities at their command, will labor to dispel the darkness which yet obscures so many of the vital processes.

EXPERIMENTAL RESEARCHES.

I.

ALBUMEN.

It is an established fact in physiology, that nitrogen is essential to the formation of all the organized tissues of the body. The experiments of Regnault and Reiset[1] have definitely determined, what had previously been arrived at by Boussingault[2] in another way, that this substance is not absorbed into the system from the atmosphere by respiration, but that there is actually, on the contrary, a loss of nitrogen to the organism from the lungs. It must, therefore, be entirely derived from the alimentary substances ingested into the stomach.

It results, therefore, that food, to be fully available for the requirements of life, must contain nitrogen in its composition, and it was, until recently, contended by many physiologists, that the nutritive value of aliments was to be directly measured by the proportion of this element entering into their constitution. It is now, however, generally admitted, that in order to conduce to the nutrition of the tissues, the nitrogen must be introduced in the form of protein.

The proteinaceous compounds ordinarily met with in the food of man, are albumen, fibrin, casein, vitellin, gluten, and legumin. The first four of these are found in animal, the latter two in vegetable food. Both the organic kingdoms of nature thus unite in providing substances containing protein, and, accordingly, whether we consider the purely carnivorous or herbivorous animal, we find

[1] Researches chimiques sur la respiration. Paris, 1849.

[2] Mémoires de chimie agricole et de physiologie. Paris, 1854, pp. 1–47. First published in Ann. de Chim. et de Phys.

that each is furnished with aliment containing a sufficiency of nitrogen to serve all the purposes of its organism.

Though the protein aliments are of such great value as organoplastic materials, it would appear, judging from experiments upon the inferior animals, that life cannot be sustained for any considerable period upon either of them alone. Tiedemann and Gmelin found it impossible to support life in geese which they fed upon pure white of egg, and the researches of other physiologists have yielded similar results. The main difficulty appears to have been, the inability of the digestive organs of the animals submitted to experiment, to assimilate a sufficient quantity of a protein compound to afford enough carbon to compensate for the loss of this substance from the lungs. Thus, Boussingault[1] fed ducks exclusively upon albumen, casein, and fibrin, and invariably found this to be the case. Too much importance, however, should not be attached to experiments of this nature. Various temporary causes affecting the solubility of the food may have existed, and great care should be exercised, before deducing inferences, and applying them to man, from investigations instituted on the lower animals. The theory (based as it is, solely in experiments upon animals far lower in the scale of creation than man), that the digestive fluids can only dissolve a limited amount of an albuminate in a given time, and that this quantity is insufficient for the demands of the system, is far from established, and has been in a great measure disproved by the recent observations of Jones.[2]

Though differing in physical characteristics, the proteinaceous substances are probably identical in chemical constitution. Albumen, the most important of them, may be regarded as the representative of the class. It is one of the chief organic constituents of the chyle and blood, from which all the tissues are elaborated, and no doubt exists that, by some means or other, the remaining members of the group, when taken into the stomach, undergo conversion into it. I have, therefore, selected it for experiment in preference to either of the others.

The investigations into the value of albumen as an article of food, and its effects upon the system, continued ten days. During this period, no other solid food was taken into the stomach, and no liquid but water. The albumen used was obtained from the serum

[1] Op. cit., p. 233, et seq.

[2] Digestion of Albumen and Flesh, &c.—*Medical Examiner*, 1856, p. 257.

of bullock's blood, by boiling it, and was consequently ingested in the coagulated form. This was the only source at my command for obtaining albumen in any quantity. It was well washed, to remove, as far as possible, all extraneous matters, and was then subjected to a temperature of 220° F., in a chloride of calcium bath, to expel all moisture. The water drank was either distilled or obtained by melting snow. The water of this region, from the springs and streams, contains so large a proportion of salts, that, had it been used, it would have interfered materially with the results. The distilled water was always well agitated with atmospheric air before being drunk. The other conditions under which the investigations were conducted, have been fully stated in the Introduction, and need not, therefore, be dwelt upon here. I omitted, however, to state, that the feces were usually evacuated immediately after rising in the morning. All deviations from this rule are specially mentioned.

At the termination of the twenty-four hours, immediately preceding the commencement of the experiments, my weight was 226.51 pounds.

FIRST DAY.

INGESTA.

8 A.M.	Albumen . . .	2980	Water . . .	7528
1 P.M.	" . . .	2562	" . . .	6350
5 "	" . . .	3187	" . . .	9580
Total	" . . .	8729	" . .	23458

EGESTA.

Kidneys.

Whole quantity of urine 16520.36.

Water	15363.07	
Solids	1157.29	
Urea		812.16
Uric acid		21.39
Chlorine		30.54
Sulphuric acid		28.65
Phosphoric acid . . .		36.17
Residue		238.38

Intestines.

Whole quantity of feces 1251.70.

Water	943.41
Solids	308.29

Ether extract	26.25
Alcohol extract . . .	89.74
Water extract	125.18
Insoluble residue . . .	67.23

Skin and Lungs.

Total loss through these channels 15059.14.

The pulse at 7 A. M. was 82, at 2 P. M. 84, and at 10 P. M. 86.—Mean 84.

The temperature of the body at the corresponding hours was respectively 96.5°, 97°, and 98.5°.—Mean 97.33°.

At 3 P. M. I abstracted 1525.80 grains of blood from the median basilic vein, which, upon analysis, was found to possess the following composition:—

1000 parts of serum—

Water	906.28
Solids	93.72
Albumen . . .	78.21
Extractive . . .	6.03
Soluble salts . . .	8.34
	92.68
Difference . . .	1.04

The whole quantity of inorganic salts in 1000 parts of serum was 10.29.

1000 parts of blood—

Water	776.45
Solids	223.55
Fibrin	2.65
Blood corpuscles .	142.09
Albumen . . .	67.00
Extractive . . .	5.11
Insoluble salts . .	6.37
	223.22
Difference . . .	.33

The whole quantity of inorganic salts in 1000 parts of blood was 7.93. In 1000 parts of defibrinated blood were 2.39 of fat.

The weight of the body at the close of the twenty-four hours was 226.20 pounds; a loss, therefore, of .31 pound, equivalent to 2170 grains, of which 1525.80 are accounted for by the blood drawn for analysis leaving 644.20 grains as the actual loss from the excretions.

The mean height of the barometer was 29.277 inches, and of the thermometer 45° F.

My appetite on this day was as good as usual. The food was sufficient to satisfy it, and was by no means unpleasant to the taste. I had no disagreeable symptoms of any kind. Sleep was sound and refreshing, and the intellectual faculties clear.

SECOND DAY.

INGESTA.

8 A.M.	Albumen . . .	3250	Water . . .	8050
1 P.M.	" . . .	2428	" . . .	7525
5 "	" . . .	2975	" . . .	9200
Total	" . . .	8653	" . .	24775

EGESTA.

Kidneys.

Whole quantity of urine 16937.62.

Water	15687.44	
Solids	1250.18	
Urea		922.39
Uric acid		22.47
Chlorine		21.54
Sulphuric acid		23.65
Phosphoric acid . . .		34.17
Residue		225.96

Intestines.

Whole quantity of feces 1353.69.

Water	1070.94	
Solids	282.75	
Ether extract		18.20
Alcohol extract . . .		75.32
Water extract		124.10
Insoluble residue . . .		71.13

Skin and Lungs.

Total loss through these channels 15556.69.

The pulse at 7 A. M. was 84, at 2 P. M. 87, and at 10 P. M. 88.—Mean 86.33.

The temperature of the body at the same hours was respectively 98°, 98.5°, and 97.5°.—Mean 98°.

My weight at the end of the twenty-four hours was 226.14 pounds; being a loss from the previous day of .06 pound, or 420 grains.

The mean heights of the barometer and thermometer were respectively 29.098 inches, and 42.50°.

I had no unusual feelings of any kind on this day; slept well.

The feces were of a very dark brown color, and of neutral reac-

tion. Crystals of ammonio-magnesian phosphate, epithelial cells, and oil and mucus globules, visible with the microscope.

THIRD DAY.

INGESTA.

8 A.M.	Albumen . . .	3760	Water . . .	8325
1 P.M.	" . . .	3000	" . . .	8490
5 "	" . . .	4525	" . . .	8420
Total	" . .	11285	" . .	25235

EGESTA.

Kidneys.

Whole quantity of urine 18428.60.

Water	17039.02	
Solids	1389.58	
Urea		1162.39
Uric acid		28.92
Chlorine		10.45
Sulphuric acid		29.18
Phosphoric acid		48.21
Residue		110.42

Intestines.

Whole quantity of feces 1628.17.

Water	1273.91	
Solids	354.26	
Ether extract		12.40
Alcohol extract		69.27
Water extract		99.68
Insoluble residue		172.91

Skin and Lungs.

Total loss from these channels 15903.23.

My pulse was at 7 A.M. 86, at 2 P.M. 88, and at 10 P.M. 89.—Mean 87.66.

The temperature of the body at the same periods was respectively 98°, 97.5°, and 98.5°.—Mean 98°.

At the termination of the twenty-four hours my weight was 226.22 pounds; a gain over the previous day of .08 pound, or 560 grains.

The mean height of the barometer was 29.245 inches, and of the thermometer 44°.

Two evacuations of the intestinal canal occurred on this day;

one at 9 P.M., the other at the regular hour. Both were in appearance, reaction, &c., similar to the discharge of the preceding day. In the evening I had slight pains in the lower part of the abdomen, and quite severe headache. Both disappeared after the first passage from the bowels. My sleep was unquiet in the early part of the night, and I awoke in the morning with headache.

In increasing so materially the quantity of albumen ingested on this day, my main object was to test more completely the power of the digestive organs. It is seen that they were fully capable of dissolving it, and that through its assimilation, enough carbon was absorbed to supply the wants of the system. This is evidenced by the increase in the weight of the body and the augmentation in the quantity of matter eliminated through the skin and lungs.

FOURTH DAY.

INGESTA.

8 A.M.	Albumen	4200	Water	8560
1 P.M.	"	4650	"	9255
5 "	"	3875	"	6350
Total	"	12725	"	24165

EGESTA.

Kidneys.

Whole quantity of urine 17483.75.

Water	15954.25	
Solids	1429.50	
Urea		1251.32
Uric acid		27.40
Chlorine		5.37
Sulphuric acid		21.18
Phosphoric acid		22.29
Residue		101.94

Intestines.

Whole quantity of feces 1827.16.

Water	1389.73	
Solids	437.43	
Ether extract		10.36
Alcohol extract		80.29
Water extract		151.47
Insoluble residue		195.31

Skin and Lungs.

Total loss through these channels 16329.09.

At 7 A.M. my pulse was 86, at 2 P.M. 90, and at 10 P.M. 98.—Mean 91.33.

At the same hours the temperature of the body was respectively 98°, 99°, and 99.5°.—Mean 98.83.

At the end of the twenty-four hours my weight was 226.32 pounds; an increase of 0.10 pound, or 700 grains.

The mean heights of the barometer and thermometer were respectively 29.230 inches, and 47.66°.

I had severe headache the whole of this day, attended with some fever. The skin was hot and dry. My appetite was not good. After each time of ingesting the albumen there was a feeling of debility in the system, accompanied with a singular sinking sensation at the epigastrium. There was also nausea at several periods of the day. The pains in the lower part of the abdomen were very severe, especially about two hours after each meal.

The feces were similar in appearance to those of the previous day; the reaction was alkaline. Crystals of ammonio-magnesian phosphate in small quantity visible with the microscope.

The urine was of high color, and of strong acid reaction—a drop evaporated to dryness on a slip of glass and placed upon the stage of the microscope, exhibited numerous needle-shaped crystals of urea.

It is perceived from the record of these experiments, that the digestive organs were capable of dissolving the large amount of albumen ingested, and that it was fully sufficient for the support of the respiratory process, and to maintain the weight of the body. The constitutional disturbance induced, warned me, however, against a repetition of so large a quantity.

FIFTH DAY.

INGESTA.

8 A.M.	Albumen . . .	1850	Water . . .	8250
1 P.M.	" . . .	2330	" . . .	7380
5 "	" . . .	2500	" . . .	8650
Total	" . . .	6680	" . .	24550

EGESTA.

Kidneys.

Whole quantity of urine 18738.50.

Water	17699.08
Solids	1039.42

	Urea		721.26
	Uric acid		18.40
	Chlorine		5.01
	Sulphuric acid		15.12
	Phosphoric acid		17.25
	Residue		262.38

Intestines.

Whole quantity of feces 1726.54.

Water	1379.30	
Solids	347.24	
Ether extract		17.29
Alcohol extract		167.52
Water extract		85.68
Insoluble residue		76.75

Skin and Lungs.

Total loss from these channels 13394.96.

At 7 A.M. my pulse was 90, at 2 P.M. 93, at 10 P.M. 104.—Mean 95.66.

At the same periods the temperature of the body was respectively 97°, 97°, and 97.5°.—Mean 97.16°.

At the end of the twenty-four hours my weight was 225.93 pounds; being a loss from the preceding day of .39 pound, equivalent to 2730 grains.

The mean height of the barometer was 29.207 inches, and of the thermometer 42.33°.

On this day I felt far from well. I had headache, and pains in the abdomen. The sinking sensation at the epigastrium was not so great as on the previous day.

Three evacuations of the bowels occurred; one at 10 A.M., one at 4 P.M., and one at 11 P.M. They were thinner, and of a darker color than previously. My physical strength was much less than usual. Appetite was not good. The sight of the albumen created disgust and nausea. Was quite restless in the night, and felt chilly towards morning. The mental faculties were not sensibly affected.

SIXTH DAY.

INGESTA.

8 A.M.	Albumen	2500	Water	7530
1 P.M.	"	1520	"	8200
5 "	"	2000	"	7550
Total	"	6020	"	23280

EGESTA.

Kidneys.

Whole quantity of urine 17530.24.

Water	16551.88	
Solids	978.36	
Urea		728.54
Uric acid		29.17
Chlorine		4.22
Sulphuric acid		12.18
Phosphoric acid		18.45
Residue		175.80

Intestines.

Whole quantity of feces 1852.15.

Water	1331.34	
Solids	520.31	
Ether extract		10.42
Alcohol extract		112.16
Water extract		136.58
Insoluble residue		261.15

Skin and Lungs.

Total loss through these channels 12927.61.

At 7 A.M. my pulse was 92, at 2 P.M. 93, and at 10 P.M. 93.—Mean 92.66.

At the same hours, the temperature of the body was respectively 96.5°, 97°, and 97.5°.—Mean 97°.

At the end of the twenty-four hours my weight was 225.50 pounds; being a loss of .43 pound, or 3010 grains.

The mean height of the barometer was 29.110 inches, and of the thermometer 42°.

I experienced on this day an increase of debility. The headache and pain in the abdomen of the preceding days were not present on this. I had very great desire for other food. The albumen was not at all relished, and it was with great effort I could bring myself to eat it. At night I slept quite well.

SEVENTH DAY.

INGESTA.

8 A.M.	Albumen . . .	3250	Water . . .	8000
1 P.M.	" . . .	4000	" . . .	8500
5 "	" . . .	3550	" . . .	7285
Total	" . .	10800	" . .	23785

EGESTA.

Kidneys.

Whole quantity of urine 16592.83.

Water	15911.08	
Solids	581.75	
Urea		390.60
Uric acid		11.28
Chlorine		3.61
Sulphuric acid		10.73
Phosphoric acid . . .		13.17
Residue		152.36

Intestines.

Whole quantity of feces 3276.40.

Water	2122.60	
Solids	1153.80	
Ether extract		11.92
Alcohol extract . . .		100.65
Water extract		75.10
Insoluble residue . . .		955.13

Skin and Lungs.

Total loss from these channels 17476.77.

My pulse was at 7 A.M. 93, at 2 P.M. 94, and at 10 P.M. 95.—Mean 94.

At the same hours the temperature of the body was respectively 97.5°, 97.5°, and 97°.—Mean 97.33°.

At the termination of the twenty-four hours my weight was 225.10 pounds; a loss, therefore, of .40 pound, equivalent to 2800 grains.

The mean height of the barometer was 29.106 inches, and of the thermometer 35.33°.

I felt weaker on this day than on any previous one of the investigations. Otherwise, I experienced no very disagreeable sensa-

tions. My skin was moist and cool during the whole day. Mental faculties active and clear.

There were two evacuations from the bowels, one at 7 P.M., the other at the usual hour. Both were of firm consistence, of the same dark-brown color, and free from strong odor. On heating a small quantity of the urine in a test tube (as had been done each day of the investigations), a precipitate, insoluble in nitric acid, ensued. This was therefore albumen.

EIGHTH DAY.

INGESTA.

8 A.M.	Albumen . . .	2980	Water . . .	7900
1 P.M.	" . . .	1855	" . . .	8280
5 "	" . . .	3740	" . . .	9525
Total	" . .	7575	" . .	25705

EGESTA.

Kidneys.

Whole quantity of urine 21235.18.

Water	20407.96	
Solids	827.22	
Urea		492.20
Uric acid		18.49
Chlorine		3.35
Sulphuric acid		11.24
Phosphoric acid . . .		11.08
Residue		290.86

Intestines.

Whole quantity of feces 3684.02.

Water	2373.10	
Solids	1310.92	
Ether extract		8.01
Alcohol extract . . .		105.27
Water extract		122.53
Insoluble residue . . .		1075.11

Skin and Lungs.

Total loss from these channels 12770.80.

At 7 A.M. my pulse was 92, at 2 P.M. 91, and at 10 P.M. 89.—Mean 90.66.

The temperature of the body at the same hours was respectively 97°, 96.5°, and 96°.—Mean 96.50°.

My weight at the end of the twenty-four hours was 224.47 pounds; being a decrease of .63 pound, equivalent to 4410 grains.

The mean heights of the barometer and thermometer were respectively 29.289 inches, and 35.33°.

With the exception of the debility, I felt tolerably well on this day. I did not, however, read or study any, and took no physical exercise beyond walking a few steps.

Two operations of the bowels occurred, one at 6 P. M., and the other at the usual hour. The feces were quite hard and similar in color and odor to those of the preceding days.

Albumen was precipitated from the urine by heat. The quantity was considerable.

NINTH DAY.

INGESTA.

8 A.M.	Albumen . . .	2150	Water . . .	5250
1 P.M.	" . . .	2200	" . . .	5690
5 "	" . . .	1800	" . . .	6000
Total	" . . .	6150	" . .	16940

EGESTA.

Kidneys.

Whole quantity of urine 12325.10.

Water	11674.86	
Solids	650.24	
Urea		329.75
Uric acid		14.81
Chlorine		2.39
Sulphuric acid		8.96
Phosphoric acid . . .		10.53
Residue		283.80

Intestines.

Whole quantity of feces 8726.50.

Water	8106.35	
Solids	620.15	
Ether extract		11.24
Alcohol extract . . .		162.95
Water extract		50.17
Insoluble residue . . .		395.79

Skin and Lungs.

Total loss from these sources 10018.40.

My pulse at 7 A. M. was 96, at 2 P. M. 98, and at 10 P. M. 104.—Mean 99.33.

At the same hours, the temperature of the body was respectively 96°, 96.5°, and 97°.—Mean 96.50°.

The weight of the body at the close of the twenty-four hours was 223.33 pounds; a loss of 1.14 pound, or 7980 grains.

The mean height of the barometer for the day was 29.235 inches, and of the thermometer 24.33°.

A serious diarrhœa of considerable violence commenced on this day. I had six evacuations of the intestines. The discharges were very thin, of a dark-brown color, and faint odor. The debility was much increased. There was dryness of the skin, and the urine was of high color. An increased amount of albumen was present in this latter excretion. My appetite was not good, neither was there much thirst. Mind clear, sleep very unquiet.

TENTH DAY.

INGESTA.

8 A. M.	Albumen . . .	1785	Water . . .	9620
1 P. M.	" . . .	1530	" . . .	8900
5 "	" . . .	1500	" . . .	9050
10 "	" . . .	——	" . . .	6525
Total	" . . .	4815	" . .	34095

EGESTA.

Kidneys.

Whole quantity of urine 21592.87.

Water	20907.63	
Solids	685.24	
Urea		340.29
Uric acid		15.31
Chlorine		2.12
Sulphuric acid		8.36
Phosphoric acid . . .		9.15
Residue		310.01

Intestines.

Whole quantity of feces 10257.30.

Water	9692.90
Solids	565.10

Ether extract	10.46
Alcohol extract . . .	182.63
Water extract	530.5
Insoluble residue . . .	318.96

Skin and Lungs.

Total loss through these sources 15319.83.

At 7 A.M. my pulse was 94, at 2 P.M. 98, and at 10 P.M. 98.—Mean 96.66.

The temperature of the body at the same hours was respectively 96.5°, 97.5°, and 98°.—Mean 97.33°.

At 3 P.M. I abstracted 1330 grains of blood from the median basilic vein. An analysis yielded the following results:—

1000 parts of serum—

Water	900.09
Solids	99.91
Albumen . . .	83.21
Extractive . . .	12.57
Soluble salts . .	3.12
	98.88
Difference . . .	1.03

The whole quantity of inorganic salts in 1000 parts of serum was 4.38.

1000 parts of blood—

Water	773.43
Solids	226.55
Fibrin	3.18
Blood-corpuscles .	137.10
Albumen . . .	71.50
Extractive . . .	11.29
Soluble salts . . .	2.14
	225.21
Difference . . .	1.34

The whole quantity of inorganic salts in 1000 parts of blood was 3.90. 1000 parts of defibrinated blood contained .74 of fat.

My weight at the termination of the twenty-four hours was 221.96 pounds; being a loss from the preceding day of 1.37 pound, or 9590 grains. Of this amount 1330 are accounted for by the blood abstracted for analysis, leaving 8260 as the loss by the excretions.

The mean height of the barometer was 28.593 inches, of the thermometer 45.66°.

The diarrhœa continued on this day with increased violence. I had eight evacuations of the same character as on the previous day. There was very little mucus contained in them, and no blood. A microscopical examination revealed the presence of cylindrical and scaly epithelium in considerable quantity.

The debility on this day was extreme, and I was obliged to lie down the greater portion of it. The intellectual faculties were somewhat confused. My sleep was restless.

The urine contained a large amount of albumen.

The investigations into the value and effects of albumen were now concluded. In a few days, under a proper diet, I began to recover my usual health. The diarrhœa ceased spontaneously on the third day. The albumen disappeared from the urine the second day after the termination of the experiments.

The results of the foregoing researches are contained in the accompanying consolidated table.

Table II.

	1st day.	2d day.	3d day.	4th day.	5th day.	6th day	7th day.	8th day.	9th day.	10th day.	Total.	Mean.
INGESTA.												
Albumen	8729	8653	11285	12725	6680	6020	10800	7575	6150	4815	83432	8343.20
Water	23458	24775	25235	24165	24550	23280	23785	25705	16940	34095	245988	24598 80
Total	32187	33428	36520	36890	31230	29300	34585	33280	23090	38910	329420	32942.00
EGESTA.												
Kidneys—												
Whole quantity of urine	16520.36	16937.62	18428.60	17483.75	18738.50	17530.24	16592.83	21235 18	12325.10	21592.87	177385.05	17738.50
Water	15363 07	15687.44	17039.02	15954.25	17699.08	16551.88	15911.08	20407 96	11674.86	20907.63	167196.27	16919.62
Solids	1157.29	1250.18	1389.58	1429.50	1039.42	978.36	581.75	827 22	650.24	685.24	9988.78	998.87
Urea	812.16	922 39	1162.39	1251.32	721.26	728.54	390.60	492.20	329.75	340.29	7150.90	715.09
Uric acid	21.39	22.47	28.92	27.40	18.40	29.17	11.28	18 49	14.81	15.31	207.64	20.76
Chlorine	30.54	21.54	10.45	5.37	5.01	4.22	3.61	3.35	2.39	2 12	88 60	8.86
Sulphuric acid	28.65	23.65	29.18	21.18	15.12	12.18	10.73	11.24	8 96	8 36	169.25	16.92
Phosphoric acid	36.17	34.17	48.21	22.29	17.25	18.45	13.17	11 08	10.52	9.15	220.47	22.04
Residue	238.38	225.96	110.42	101.94	262.38	175.80	152.36	290.86	283.80	310.01	2151.91	215 19
Intestines—												
Whole quantity of feces	1251.70	1353.69	1628.17	1827.16	1726.54	1852.15	3276.40	3684.02	8726.50	10257.30	35583.63	3558.36
Water	943.41	1070.94	1273.91	1389.73	1379.30	1331.34	2122.60	2373.10	8106.35	9692 90	29683.58	2968.35
Solids	308.29	282.75	354.26	437.43	347.24	520.31	1153.80	1310.92	620.15	565.10	5900.25	590.02
Ether extract	26.25	18.20	12.40	10.36	17.29	10.42	11.92	8.01	11.24	10.46	136.55	13.65
Alcohol extract	89.74	75.32	69.27	80.29	167.52	112.16	100.65	105 27	162.95	182.63	1145.80	114.58
Water extract	125.18	124.10	99 68	151 47	85 68	136.58	75.10	122.53	50 17	53.05	1023.54	102.35
Insoluble residue	67.23	71.13	172.91	195.31	76.75	261.15	955.13	1075.11	305.79	318.96	3589.47	358.94
Skin and Lungs—												
Total loss from	15059.14	15556.69	15903.23	16329.09	13394.96	12927.61	17476.77	12770 80	10018.40	15319.83	144756.52	14475.65
Total egesta	32831.20	33848.00	35960.00	36190.00	33960.00	32310.00	37385.00	37690.00	31070.00	47170.00	358414.20	35841.42
Variation in weight	—644.20	—420.00	+560.00	+700.00	—2730.00	—3010.00	—2800.00	—4410.00	—7980.00	—8260.00	28894.20	—28994.20
Pulse	84	86.33	87.66	91.33	95.66	92.66	94.00	90.66	99.33	96.66	..	91.83
Temperature of body	97.33°	98°	98°	98.83°	97.16°	97°	97.33°	96.50°	96.50°	97.33°	..	97.39°
Barometer	29.277	29.098	29.245	29.230	29.207	29.110	29.106	29.289	29.235	28.593	..	29.139
Thermometer	45°	42.50°	44°	47.66°	42.33°	42°	35.33°	35.33°	24.33°	45.66°	..	40.41°

Upon a consideration of the results of the foregoing investigations, and comparing them as far as possible with those obtained whilst I was living on a normal and ordinary diet, it is seen that the following effects in the mean ensued :—

Kidneys.—The *whole quantity of urine* was lessened, as were also the absolute amounts of *water* and *solids.* Relatively, the solids were increased in quantity. The urine was, therefore, more concentrated.

The quantity of *urea* was increased, though not so much so in the mean as was to have been anticipated.

The amount of *uric acid* eliminated was very much increased.

The proportion of *chlorine* was greatly reduced.

The *sulphuric* and *phosphoric acids* were lessened in quantity.

The *residue* was increased in amount.

Intestines.—The *whole quantity of feces* was augmented. This result was entirely due to the diarrhœa of the 9th and 10th days. More than half of the whole amount of feces was passed on these days. Throwing them out of the calculation, and it is seen that the mean quantity of feces for the remaining eight days was less than the mean of the five days of the standard series.

The *water* of the feces was greatly increased. This was owing to the same cause as the augmentation of the whole quantity of feces.

The *solids* were reduced in amount.

The *ether extract* was much lessened. It is seen, however, that there was a considerable quantity, notwithstanding no fat was ingested.

The *alcohol extract* was rendered greater in amount.

The *water extract* was diminished in quantity.

The *insoluble residue* was increased.

Skin and Lungs.—No comparison of the losses from these channels during the two series of investigations can be made; as, in the first series, they were not determined. It is perceived, however, that the general effect of increasing the amount of albumen ingested, was to augment the proportion of loss from these sources.

The *weight of the body* is seen in the mean to have materially declined.

The *pulse* was increased in frequency.

The *temperature of the body* was slightly reduced.

The effects of an exclusively albuminous diet upon the consti-

tution of the *blood*, will be more clearly perceived from the following table of the first and tenth days' analysis:—

TABLE III.

1000 parts of serum—	1st day.	10th day.	1000 parts of blood—	1st day.	10th day.
Water	906.28	900.09	Water	776.45	773.43
Solids	93.72	99.91	Solids	223.55	226.55
Albumen	78.28	83.21	Fibrin	2.65	3.18
Extractive . . .	6.03	12.57	Blood-corpuscles .	142.09	137.10
Soluble salts . .	8.34	3.12	Albumen	67.00	71.50
Whole quant. inorg. salts	10.29	4.38	Extractive . . .	5.11	11.29
			Soluble salts . . .	6.37	2.14
			Whole quant. inorg. salts	7.93	3.90
			Fat in 1000 parts defibrinated blood	2.39	.74

From this table it is perceived, that under the diet of albumen, the *water*, *soluble* and *whole quantity* of *inorganic salts* of the *serum* were diminished, and the *solids*, *albumen*, and *extractive* increased in quantity. In the *whole blood* there was a diminution of the *water*, *blood-corpuscles*, *soluble* and *total amount* of *inorganic salts*, and *fat*, whilst there was an augmentation of the *solids*, *fibrin*, *albumen*, and *extractive.*

The main results of the foregoing investigations I propose to consider more at length under the following heads:—

1. The capability of the digestive organs to dissolve and the absorbents to assimilate, a sufficient quantity of albumen to support the calorifacient process.

2. The relation which the nitrogen of the urea and uric acid excreted, bears to the amount absorbed with the albumen.

In relation to the first head, physiologists are not disposed to accord a high value to albumen as an article of respiratory food. The elementary analysis of albumen shows that it does not contain all those substances which enter into the composition of the tissues of the body. It cannot, therefore, of itself, support life or health. and the functional derangements which attended its use during the foregoing investigations, abundantly establish this fact. I am very far, therefore, from claiming for it any such power. Nevertheless, I think it is fully proven, that before the general health becomes injured by a too long exclusive use of albumen, enough of this substance can be assimilated to repair the waste of the tissues, and support the respiratory function.

According to Liebig,[1] an adult man daily consumes $13\frac{9}{10}$ ounces (a little over 6000 grains) of carbon, which passes from the system by the lungs and skin as carbonic acid gas. Scharling[2] states, as the result of his researches, that a powerful adult man exhales from the lungs 867 grammes (about 13,438 grains) of carbonic acid daily. This quantity of carbonic acid is equivalent to 3664.90 grains of carbon. According to Andral and Gavarret,[3] a man twenty-six years of age exhales daily 4065 grains of carbon. Carpenter[4] is of the opinion that 3840 grains is the average daily amount of carbon given off through the lungs of a well-grown adult man.

From a series of researches instituted upon myself, with the object of ascertaining the effects of alcohol and tobacco upon the human system, I found that an average of 11674.98 grains of carbonic acid (equivalent to 3185.44 grains of carbon) were daily exhaled from the lungs. The method of determination was, however, imperfect, and the absolute amount was doubtless greater than is stated.

The preceding experiments with albumen show, that on the first and second days of the series, the body slightly decreased in weight, and that on the third and fourth days a small increase ensued. On these days, the quantity of albumen ingested was greater than on the first two days; and, that an increased amount was assimilated is evident from the comparatively small quantities of water extract and insoluble residue obtained from the feces. The fact that the bowels were regularly evacuated, shows that the increase of weight observed was not due to any obstruction of the intestinal canal, and consequent accumulation of matter in that channel. Besides the above facts, the great increase in the amount of urea eliminated by the kidneys on the days referred to, is also indicative of an augmented assimilation of albumen.

On the fifth day, the body commenced rapidly to lose weight. The effects of so exclusive a regimen began to act injuriously upon the system, while febrile excitement, and other symptoms indicative of derangement of the health, were present; and on the seventh day, notwithstanding a great increase in the quantity of albumen ingested, a loss of weight to the extent of 2800 grains occurred. Albumen appeared in the urine on this day, and of the

[1] Letters on Chemistry, p. 315, Lond. ed.

[2] Lehmann's Physiological Chemistry, vol. ii. p. 435, Amer. ed.

[3] Quoted in Carpenter's Physiology, p. 526.

[4] Physiology, p. 526.

amount taken into the stomach, over 1000 grains were recovered from the excrement. The loss from the skin and lungs was unusually great.

The following table, showing the amount of albumen daily absorbed into the system from the intestinal canal, and the quantity of carbon entering into its composition, will serve to place the subject in a more evident light. The proportion of assimilated albumen is found by deducting the collective amount of water extract and insoluble residue of the feces, from the total quantity of albumen ingested. In the estimation of the carbon contained therein, I have adopted the analysis of Dumas and Cahours,[1] of the albumen derived from the serum of beef's blood.

TABLE IV.

	1st day.	2d day.	3d day.	4th day.	5th day.	6th day.	7th day.	8th day.	9th day.	10th day.	Mean.
Absorbed albumen	8536.59	8455.77	11012.41	12318.22	6517.57	5622.27	9769.76	6377.36	3704.04	4442.99	7895.69
Absorbed carbon	4559.53	4515.37	5860.62	6577.92	3480.38	3002.29	5118.05	3406.51	3045.95	2372.53	4216.30

According to the above table, on only one day (the 4th), did the amount of absorbed carbon equal the wants of the system, if we accept Liebig's estimate of the quantity ordinarily given off by the skin and lungs. On the 3d day, the proportion of carbon entering the system did not fall much below Liebig's standard. On these two days only (as we have seen) did the body gain weight. On all the remaining days, except the 7th (and on this day it was nearly 900 grains less than Liebig's estimate calls for), the quantity of the absorbed carbon was much below the requirements of the organism, and in the mean, was 1800 grains less than the average amount excreted through the skin and lungs, as stated by Liebig.

Leaving, however, all deductions based upon the estimates of others, the broad fact appears, that on the 3d and 4th days of the foregoing researches, not only was enough albumen assimilated to compensate for the total loss from the excretions, but new matter was deposited in quite an appreciable amount. On the 3d day, too, the temperature of the body was fully up to the natural standard, and on the 4th, very materially exceeded it. Without entering further into the details of this point, I think the conclusion is fully supported, that the digestive organs can dissolve enough albumen

[1] Violette et Archambault, Dictionnaire des Analyses Chimiques, p. 62.

to supply the system with the necessary amount of carbon. If the albumen ingested during these experiments had been conjoined with such mineral substances, in such quantities as the blood and tissues require, in order that nutrition may be perfect, it would doubtless have been better borne by the system, and could have been taken in much larger quantities. Under such circumstances, no good reason can be given, why albumen should not have answered all the purposes of plastic formations, and at the same time, have sustained the heat producing function at the proper degree of action.

Whether the opinion of Bidder and Schmidt,[1] that the gastric juice is not secreted in sufficient quantity to dissolve and metamorphose the necessary amount of albumen for the above purposes, and that the intestinal juice[2] is equally as important an agent in effecting these changes, or whether the view of Frerichs and Lehmann,[3] who could discover no such power in the latter fluid, be correct, did not come within the range of these investigations to determine. Contrary, however, to Boussingault's[4] conclusions, based upon his experiments on ducks, and to the indorsement of his view by Lehmann,[5] I think the deduction drawn from the present researches is fully supported by the direct results obtained—at least, so far as regards man, whose physiology it is of the greatest importance thoroughly to understand.

2d. The relation which the nitrogen of the urea and uric acid excreted, bears to the amount absorbed with the albumen.

The relation which the nitrogen excreted by the kidneys has to that taken into the system with the food, is far from being definitely determined, notwithstanding the numerous experiments made with the object of settling the point.

Two views in regard to the origin of urea are held by those who have investigated the subject; one party, of which Lehmann, Frerichs, and Bidder and Schmidt, are specially to be mentioned, maintaining that it is derived both from the decomposition of the tissues of the body and from the oxidation of the albuminates taken as food, whilst the other, of which Liebig and Bischof are the heads, claiming that it is solely derived from the former source.

[1] Die Verdauungssaefte und der Stoffwechsel.—Vom Magensafte, p. 29.

[2] Op. cit.—Vom Darmsafte, p. 260.

[3] Physiological Chemistry, vol. i. p. 510.

[4] Mémoires de Chimie Agricole et de Physiologie, pp. 235, 236.

[5] Physiological Chemistry, vol. ii. p. 495 (Am. ed.).

Whether nitrogenous food is first converted into tissue before its elimination as urea, or whether it undergoes oxidation into this substance whilst still in the blood, it would seem impossible in the present state of our knowledge to decide. The foregoing investigations, whilst they cannot be considered as determining this point, afford some very striking results, and throw some additional light upon the subject.

The following table exhibits for each day of the series, the proportion of nitrogen in the absorbed albumen, the amount excreted with the urea and uric acid, and the ratio which the nitrogen contained in these substances bore to 100 parts of the quantity which was taken into the organism.

TABLE V.

	1st day.	2d day.	3d day.	4th day.	5th day.	6th day.	7th day.	8th day.	9th day.	10th day.	Mean.
Absorbed nitrogen	1340.24	1311.55	1728.94	1933.86	1023.25	882.69	1533.85	1001.24	905.53	697.54	1235.87
Excreted with urea	378.95	430.38	542.37	583.86	336.53	340.67	182.24	385.98	153.87	314.58	364.94
Excreted with uric acid	7.13	7.49	9.64	9.13	6.13	9.72	3.76	6.16	4.93	5.10	6.91
Total	386.08	437.87	552.01	592.99	342.66	350.39	186.00	392.14	158.80	319.68	371.85
Excreted for each 100 parts absorbed.	29.55	33.38	32.50	30.66	33.48	39.69	12.12	39.16	17.53	45.81	30.08

From the above table it is seen that the greatest proportional elimination of nitrogen, in the form of urea and uric acid, occurred on the 6th, 8th, and 10th days, and the smallest on the 7th and 9th. In the mean, 30.08 parts per hundred taken into the system, appeared again in the urine, as urea and uric acid.

This result, certainly varies greatly from those obtained by any other observer to whose investigations I have had the opportunity of referring. The experiments of Rigg[1] and of Barral,[2] gave results most nearly in accordance with my own, but there is still a wide difference. The former of these physiologists found that for every 100 parts of absorbed nitrogen, 50.8 were excreted in the urine; the latter, for 100 parts of nitrogen entering the system, found 42.07 in this excretion.

Other physiologists have arrived at results yet more at variance with mine. Lehmann[3] found, that whilst living on a purely animal

[1] Lehmann's Physiological Chemistry, vol. ii. p. 497, 498.
[2] Ibid. [3] Ibid.

diet, five-sixths of the nitrogen taken into the system was given off again by the kidneys. Bidder and Schmidt[1] found, that in a cat, which in 24 hours absorbed 8.604 grammes of nitrogen, 7.786 grammes appeared in the urine. Bischof[2] (among other examples) found, that of 54.09 grammes of nitrogen entering the system of a dog, 29.45 grammes were contained in the excreted urea. It is true, Boussingault[3] recovered from the urine but 37.8 grammes of nitrogen of 139.4 contained in the food of twenty-four hours of a horse, but the excess was in this instance, discharged as a constituent of the feces.

In the present experiments, but a small portion of nitrogen could have been discharged by the urine, as a constituent of other substances than urea or uric acid. The amount of residue, whose exact composition was undetermined, was never very large till towards the last, and although albumen was discovered in the urine after the sixth day, the quantity was not such as to make much difference in the proportions given in Table V. The amount of nitrogen eliminated by the feces was of course very small. (It is to be recollected in this connection, that in estimating the quantity of albumen entering the organism, the unassimilated residue found in the feces, is deducted from the gross amount ingested.)

69.92 grains of nitrogen in every 100 entering the circulation were excreted from the system under some other form than as urea or uric acid, or that proportion, formed new combinations, and was retained within the organism. It is difficult to perceive how this enormous amount could have been given off by the lungs and skin, especially as the most exact observations upon animals have determined the loss of nitrogen through these channels to be exceedingly small.

Frequently, during each day of the investigations, I held a glass rod previously dipped in hydrochloric acid, in the current of the expired air, and, though the white fumes of chloride of ammonium were sometimes produced, this was very seldom, and never in any considerable amount. The skin, during the experiments, had no ammoniacal odor, which would have been present if ammonia in any quantity had been given off.

In view of these facts, I cannot think that the excess of nitrogen escaped from the system as ammonia.

[1] Die Verdauungssaefte und der Stoffwechsel. Tab. v. s. 306.

[2] Der Harnstoff als Maas des Stoffwechsels, s. 65.

[3] Mémoires de Chimie Agricole et de Physiologie, p. 15, et seq.

The only conclusion remaining is, that the greater part of the absorbed nitrogen continued in the organism either as albumen or under the form of other combinations. The decrease of weight in the body, which occurred on every day but the third and fourth, was doubtless mainly owing to the oxidation of a portion of the fat, and is not incompatible with the formation of new matter of an entirely different character.

On a reference to Table II, it is seen that the nitrogenous matters of the blood (fibrin, albumen, and extractive) were very materially augmented in quantity, and that the fat was greatly diminished. These facts constitute a strong additional argument in favor of the supposition advanced above, and tend to support the view of Bischof,[1] that the albuminates of the blood must pass through other processes before they can, merely by the action of oxygen, undergo metamorphosis into urea.

In view of these circumstances, I am disposed to conclude:

1st. That the proportion of nitrogen eliminated by the kidneys to that absorbed into the circulation is, in man, much less than is generally supposed.

2d. That even when the body is losing weight from the oxidation of its fat, the excess of nitrogen over that escaping by the kidneys is retained in the system, both in its original form, and under that of other combinations.

One of the most important results of the foregoing experiments was the discovery of the presence of albumen in the urine. This it is seen was not made until the seventh day, from which time, this substance was not absent during the researches; and subsequent observations showed, that it was a constituent of the excretions for four days after the conclusion of the series.

The fact that albumen is found in the urine has been before noticed in other connections than as associated with granular degeneration of the kidneys. Professor Walshe[2] is of opinion, that it may occur from other diseases, and from the use of certain articles of food. Begbie[3] states, that it may be present in the urine of perfectly healthy persons, in certain conditions of the system (as pregnancy) in certain acute and inflammatory diseases, after eating particular kinds of food (as pastry) after certain remedies (as juni-

[1] Der Harnstoff als Maass des Stoffwechsels, s. 141.

[2] London Lancet, 1849, p. 416.

[3] British and Foreign Medico-Chirurg. Review, July, 1853, p. 46.

per), and after the application of blisters. Bernard[1] mentions the case of a man, who, after eating a large number of raw eggs after fasting, had albumen present in his urine. Bernard, however, is of opinion, that it is only under such conditions, viz., an empty state of the digestive organs, and the sudden ingestion of a large quantity of albuminous food, that such an event can ensue, and Rees[2] denies entirely, that this substance is ever found in the urine as the result of an albuminous diet.

The present researches show, that albuminuria is produced by the continued use of highly albuminous food in large quantities, and that it was not (so to speak) until the system was saturated with albumen, that it made its appearance in the urine.

Without stopping to discuss the other points of these experiments, I proceed to detail the results of the second series, with starch.

II.

STARCH.

The amylaceous substances were, until recently, regarded as being peculiar to vegetable bodies, and the fact of a being presenting distinct evidences of containing them, was sufficient to deny it all claim to an animal existence. This distinctive test, however, can no longer be relied upon. C. Schmidt first showed that cellulose (a substance isomeric with starch) existed as a constituent of the mantle of certain of the tunicata. Gottlieb discovered paramylon (also isomeric with starch) in the body of the infusorium (?) *Euglena viridis*, and other observers, among whom Kölliker, Lœwig, Schacht, and Huxley,[3] are to be mentioned, have fully demonstrated the truth of Schmidt's discovery.

Within a short period, Virchow[4] has carried the investigation still further, and has shown that the corpora amylacea of the human

[1] Leçons de Physiologie expérimentale. Cours de semestre d'hivers, 1854—1855.

[2] London Medical Gazette, vol. xiii. 1851, p. 49.

[3] For translations of Schacht's and Virchow's papers, and Huxley's original article, see Quarterly Journal of Microscopical Science, Nos. 1, 2, 6, 12, and 14.

[4] Ibid.

brain are composed of cellulose, and that this substance is also met with in other parts of the body as the result of a certain diseased condition, which he designates as amyloid degeneration.

Busk,[1] however, who has examined this subject very attentively, is of the opinion that the corpuscles in the brain, designated as cellulose by Virchow, are, in fact, starch, "possessing all the structural, chemical, and optical characters of this substance, as it occurs in plants." It may therefore be assumed as a physiological truth, that amylaceous substances are not peculiar to vegetables, but are also constituents of the bodies of man, and other animals.

From the fact that starch contains no nitrogen in its composition, it cannot contribute to the nutrition of the tissues. Its value, therefore, is generally regarded as resting solely on its heat producing power. In this respect, its easy digestibility renders it superior to fatty substances, although the latter contain a greater proportion of combustible material. Boussingault[2] fed a duck exclusively upon bacon, and found that enough was not assimilated in a given time to repair the loss through the respiratory process. Another duck, fed upon starch, absorbed nearly twice as much as was sufficient to furnish carbon for the wants of the system.

With regard to the process by which starch is digested, much light has been afforded by the labors of recent investigators. Leuchs first established the fact that the saliva possesses the property of changing starch into sugar. Bidder and Schmidt[3] state, as the result of numerous experiments, that when the saliva of adult men was mixed with a solution of starch, the conversion into sugar began instantaneously. They also show, that other juices, and certain tissues of animals, possess the faculty of effecting this metamorphosis.

On the other hand, Bernard,[4] whilst believing that the saliva, under favorable circumstances, out of the body, is capable of transforming starch into sugar, denies it this power within the system, by reason of the short time it is in contact with the food in the mouth, and the fact that the metamorphosis in the stomach is entirely prevented by the gastric juice. He is of opinion that the

[1] Quarterly Journal of Microscopical Science, No. vi. p. 115.

[2] Mémoires de Chimie agricole et de Physiologie, p. 230.

[3] Die Verdauungssaefte und der Stoffwechsel. S. 17.

[4] Leçons de Physiologie expérimentale. Cours de semestre d'été. 1855, p. 155 et seq.

change of starch into sugar is almost solely due to the action of the pancreatic and intestinal juices.

Mialhé[1] combats these views of Bernard, and whilst admitting that the conversion of starch into glucose, initiated by the saliva, may be arrested in the stomach by the acid of the gastric juice, contends, that the former fluid exercises a very powerful influence in effecting the transformation.

Some recent experiments of Professor F. G. Smith,[2] of Philadelphia, would seem to determine this point. Prof. S. found in the case of Alexis St. Martin (the individual upon whom Dr. Beaumont's experiments were instituted), that after eating farinaceous food, sugar was invariably discovered in the contents of the stomach, and concludes "that the human gastric juice does not prevent the conversion of starch into grape sugar, and that this change may take place in the stomach independently of the action of the saliva." His investigations appear to have been conducted with great care, and I shall therefore adopt his conclusions.

The change which is commenced by admixture of the amylaceous food with the saliva in the mouth, is continued in the stomach, by the quantity of this secretion swallowed with the aliment. The gastric, pancreatic, and intestinal juices, especially the second named, assist in the process, and eventually, through the combined influence of these several secretions, the starch is brought into a fit form for assimilation. The greater part is absorbed into the circulation as grape sugar, a portion undergoes continued metamorphosis into lactic and butyric acids, and occasionally another part, which has escaped alteration, is discharged with the alvine dejections.

Such is a very condensed outline of some of the principal points of interest connected with the substance under consideration. I now proceed to state my own investigations.

The starch used in these experiments was of the form generally known as corn-starch, and being manufactured for table use, was of a purer quality than the ordinary article. It was always cooked before ingestion, but was taken free from any other substance than the necessary amount of water. The figures in the following pages expressive of the quantity of starch ingested, refer to the dry substance before it was cooked; those relating to the amount of water, refer both to that portion of this liquid taken with the starch, and

[1] Chimie appliquée à la Physiologie, etc., p. 38, et seq.

[2] Medical Examiner, September, 1856, p. 513, et seq.

the quantity drank. The water used was either distilled, or snow or rain water.

The investigations were performed under the same conditions (other than the food) as the former series, and as stated at length in the introduction. Such deviations from the standard course as were unavoidable, are specially noted. The researches continued ten days.

Thirty days elapsed from the conclusion of the experiments with albumen till the commencement of the present series. In that time, my health had entirely recovered, and the weight of the body had undergone a small, but steady increase.

At the end of the twenty-four hours immediately preceding the commencement of the following researches, my weight was 224.87 pounds.

FIRST DAY.

INGESTA.

8 A.M.	Starch	3000	Water	8550
1 P.M.	"	4000	"	8500
5 "	"	2500	"	7450
Total	"	9500	"	24500

EGESTA.

Kidneys.

Whole quantity of urine 14339.51.

Water	13588.69	
Solids	750.82	
Urea		421.57
Uric acid		6.34
Chlorine		85.26
Sulphuric acid		30.45
Phosphoric acid		27.18
Residue		180.02

Intestines.

Whole quantity of feces 1041.86.

Water	816.96	
Solids	224.90	
Ether extract		49.72
Alcohol extract		50.29
Water extract		30.18
Insoluble residue		94.71

Skin and Lungs.

Total loss through these channels 19798.34.

My pulse at 7 A.M. was 80, at 2 P.M. 82, and at 10 P.M. 84.—Mean 82.

The temperature of the body at the above hours was respectively 98°, 97.5°, and 97°.—Mean 97.50°.

At 3 P.M. I abstracted 1480.29 grains of blood from the median basilic vein. The following is the analysis:—

1000 parts of serum—

Water	907.34
Solids	92.66
Albumen	75.02
Extractive	6.18
Soluble salts	10.72
	91.92
Difference	.74

The whole quantity of inorganic salts in 1000 parts of serum was 11.98.

1000 parts of blood—

Water	779.33
Solids	220.77
Fibrin	1.99
Blood-corpuscles	141.18
Albumen	63.66
Extractive	4.84
Soluble salts	9.31
	220.98
Difference	.21

The whole quantity of inorganic salts in 1000 parts of blood was 10.42. In 1000 parts of defibrinated blood was 1.83 of fat.

The weight of the body at the end of the twenty-four hours was 224.49 pounds; being a loss of .38 pound, or 2660 grains; of which 1480.29 are represented by the amount of blood drawn for examination, leaving 1179.71 as the excess of loss from the excretions.

The mean height of the barometer for the twenty-four hours was 29.276 inches, and of the thermometer 1.66°.

On this day I had no abnormal symptoms of any kind. My appetite was very good, and the starch was relished as a pleasant article of food. At night, slept well. I took but very little physical exercise on this day, owing to the extreme coldness of the weather.

SECOND DAY.

INGESTA.

8 A.M.	Starch	3000	Water	6250
1 P.M.	"	3500	"	10000
5 "	"	4000	"	10000
Total	"	10500	"	26250

Egesta.

Kidneys.

Whole quantity of urine 14970.83.

Water	14327.62	
Solids	643.21	
Urea		369.15
Uric acid		5.42
Chlorine		31.04
Sulphuric acid		19.68
Phosphoric acid		25.97
Residue		183.95

Intestines.

Whole quantity of feces 1076.53.

Water	858.18	
Solids	218.35	
Ether extract		51.36
Alcohol extract		39.12
Water extract		24.39
Insoluble residue		103.48

Skin and Lungs.

Total loss through these channels 21122.64.

My pulse was at 7 A. M. 83, at 2 P. M. 85, and at 10 P. M. 84.—Mean 84.

At the same periods the temperature of the body was respectively 98°, 98.5°, and 98°.—Mean 98.16°.

The weight of the body at the end of the twenty-four hours was 224.43 pounds; a loss of .06 pound, or 420 grains.

The mean height of the barometer was 29.086 inches, and of the thermometer 3°.

No unusual symptoms of any kind occurred. Appetite good, sleep sound and refreshing. At about 9 P. M., through inadvertence, I drank two ounces of hot whiskey punch.

THIRD DAY.

Ingesta.

8 A.M.	Starch	3300	Water	8900
1 P.M.	"	3500	"	9526
5 "	"	4500	"	10500
Total	"	11300	"	28926

EGESTA.

Kidneys.

Whole quantity of urine 19735.24.

Water	19296.09	
Solids	439.15	
Urea		225.06
Uric acid		5.18
Chlorine		14.27
Sulphuric acid		12.07
Phosphoric acid		26.61
Residue		155.96

Intestines.

Whole quantity of feces 925.01.

Water	724.47	
Solids	200.54	
Ether extract		45.13
Alcohol extract		28.74
Water extract		35.41
Insoluble residue		91.26

Skin and Lungs.

Total loss from these channels 18585.75.

My pulse at 7 A.M. on this day was 82 per minute, at 2 P.M. 84, and at 10 P.M. 85.—Mean 83.66.

The temperature of the body at the same hours was respectively 98°, 98°, and 98.5°.—Mean 98.16°.

My weight at the end of the twenty-four hours was 224.57; showing an increase over the preceding day of .14 pound, or 980 grains.

The mean height of the barometer was 29.213 inches; that of the thermometer was 4.66°.

Notwithstanding the increase of weight, I felt somewhat weak on this day. My appetite was excellent, and the starch was still relished. The urine was of a somewhat darker color than usual. Numerous starch granules were discovered in the feces by the microscope.

FOURTH DAY.

INGESTA.

8 A.M.	Starch . . .	3000	Water . . .	8500
1 P.M.	" . . .	3500	" . . .	9500
5 "	" . . .	5500	" . .	11000
Total	" . .	12000	" . .	29000

EGESTA.

Kidneys.

Whole quantity of urine 20245.10.

Water	19787.10	
Solids	458	
Urea		204.29
Uric acid		7.53
Chlorine		8.41
Sulphuric acid		10.55
Phosphoric acid . . .		18.29
Residue		216.74

Intestines.

Whole quantity of feces 1438.15.

Water	1013.08	
Solids	425.07	
Ether extract		40.26
Alcohol extract . . .		29.13
Water extract		28.64
Insoluble residue . . .		327.01

Skin and Lungs.

Total loss through these channels 18476.25.

My pulse at 7 A.M. was 82, at 2 P.M. 84, and at 10 P.M. 84.—Mean 83.33.

At the same hours the temperature of the body was respectively 98.5°, 99°, and 99°.—Mean 98.83°.

At the termination of the twenty-four hours my weight was 224.79 pounds; an increase over the preceding day of .12 pound, equivalent to 840 grains.

The mean height of the barometer was 29.366 inches, and of the thermometer 0.66°.

I felt a good deal of debility during this day, my mind was not active, and there was great indisposition to physical exertion. The appetite was good, but, for the first time, there was some little dis-

taste for the starch, and a great desire to mix salt with it. I experienced at intervals during the day a feeling of oppression about the lungs, which was only relieved by a full inspiration; at night had frequent dreams of falling from precipices, and awoke several times with a sudden start. I also noticed, that the saliva was unusually thick and ropy. Under the microscope, an extraordinarily large number of epithelial cells and mucus globules were discovered. It was neutral to test paper.

FIFTH DAY.

INGESTA.

8 A.M.	Starch	3000	Water	8000
1 P.M.	"	3800	"	9000
5 "	"	4000	"	10000
Total	"	10800	"	27000

EGESTA.

Kidneys.

Whole quantity of urine 18275.82.

Water	17885.11	
Solids	390.71	
Urea		160.47
Uric acid		7.26
Chlorine		8 03
Sulphuric acid		6.70
Phosphoric acid		10.55
Residue		197.70

Intestines.

Whole quantity of feces 1145.90.

Water	937.68	
Solids	205.22	
Ether extract		35.78
Alcohol extract		30.65
Water extract		20.50
Insoluble residue		118.29

Skin and Lungs.

Total loss through these channels 18518.28.

My pulse at 7 A.M. was 85, at 2 P.M. 87, and at 10 P.M. 87.—Mean 86.33.

The temperature of the body at the same hours was respectively 98.5°, 99°, and 99.5°.—Mean 99°.

At the end of the twenty-four hours my weight was 224.77 pounds; showing a loss of .02 pound, or 140 grains.

The mean height of the barometer was 29.510 inches, and of the thermometer 1°.

On this day I felt exceedingly feeble. The mind was dull, and it required an effort to fix it upon any subject. Scarcely any physical exercise was taken. The feeling of oppression at the chest had increased, and there was a good deal of sighing respiration. At 12 M., and at 4 P. M., had slight palpitation of the heart. There was some pain in the abdomen through the day, and a large quantity of flatus was discharged with the feces. Slept better than on the previous night, but awoke in the morning with a most intense pain over the left supraorbital arch. This was so severe that I was unable to endure it, and I took forty grains of magnesia with almost instantaneous relief; showing that in all probability the headache was caused by acidity of the stomach. The saliva was of the same character as on the previous day. The microscope still showed an unusual amount of epithelial scales and mucus globules. Reaction neutral.

The urine passed, on rising from bed, was of a darker color than at any time previous during this series of experiments. On testing it for sugar, by Trommer's method (as had been done every day during the investigations), there was a clear and well marked precipitate of the suboxide of copper. The fermentation test, and examination with the microscope for the *torula cerevisiæ*, were both subsequently applied with affirmative results.

SIXTH DAY.

INGESTA.

8 A.M.	Starch . . .	2500	Water . . .	6200
1 P.M.	" . . .	3500	" . . .	9050
5 "	" . . .	4000	" . .	10000
Total	" . .	10000	" . .	25250

EGESTA.

Kidneys.

Whole quantity of urine 15160.06.

Water	14631.87
Solids	528.19

Urea	176.28
Uric acid	8.49
Chlorine	6.22
Sulphuric acid	4.12
Phosphoric acid	5.64
Residue	347.84

Intestines.

Whole quantity of feces 1097.

Water	910.47	
Solids	186.53	
Ether extract		29.89
Alcohol extract		34.75
Water extract		14.65
Insoluble residue		107.24

Skin and Lungs.

Total loss through these channels 18782.94.

The pulse at 7 A.M. was 85 per minute, at 2 P.M. 85, and at 10 P.M. 90.—Mean 87.66.

At the same periods the temperature of the body was respectively 99°, 99°, and 99.5°.—Mean 99.16°.

At the termination of the twenty-four hours my weight was 224.81 pounds; an increase of .03 pound, or 210 grains.

The mean height of the barometer was 29.426 inches, and of the thermometer 9.33°.

The debility was still present. Notwithstanding the magnesia taken the previous day, there was considerable torpor of the bowels. Mental phenomena unchanged. The skin was hot, and there was some fever towards night. The oppression at the chest had, in a measure, subsided. The palpitation of the heart, however, still remained, and was very annoying. I was also troubled a good deal with pyrosis. Rested well at night.

All the urine discharged on this day exhibited (with the tests previously employed) undoubted evidences of containing sugar. The saliva was more natural in its character, though of very feeble alkaline reaction.

My friends noticed, by this time, a change in my personal appearance. My countenance was unusually pale, and my lips of a slight bluish tinge; showing deficient aëration of the blood, or an excessive accumulation of carbonaceous matter in the system.

SEVENTH DAY.

INGESTA.

8 A.M.	Starch . . .	2500	Water . . .	7000
1 P.M.	" . . .	3500	" . . .	8000
5 "	" . . .	3500	" . . .	9300
Total	" . .	9500	" . .	24300

EGESTA.

Kidneys.

Whole quantity of urine 15282.25.

Water	14856.45	
Solids	425.80	
Urea		157.05
Uric acid		8.36
Chlorine		4.74
Sulphuric acid		3.81
Phosphoric acid		5.70
Residue		244.14

Intestines.

Whole quantity of feces 946.17.

Water	750.70	
Solids	195.47	
Ether extract		33.76
Alcohol extract		34.29
Water extract		27.42
Insoluble residue		100.

Skin and Lungs.

Total loss by these channels 17921.58.

At 7 A.M. the pulse was 87, at 2 P.M. 89, and at 10 P.M. 93.—Mean 89.66.

At the above hours, the temperature of the body was respectively 98°, 98.5°, and 98.5°.—Mean 98.33°.

At the end of the twenty-four hours the weight of the body was 224.76 pounds; a decrease of .05 pound, or 350 grains.

The mean height of the barometer was 29.141 inches, that of the thermometer 12.33°.

The palpitation of the heart was very troublesome on this day, as was also the pyrosis. Debility excessive, especially in the muscles of the back. The desire for other food was very great. The starch was by this time exceedingly disagreeable. One or two

slight scratches, which I had received on the hand the day before, became painful, and showed a tendency to inflammation and suppuration. Such a thing had never happened to me before; my flesh always healing readily after such injuries. I did not sleep well, was quite feverish during the night, and awoke in the morning with severe headache.

The urine was still saccharine, of a dark-brown color, and very acid reaction. Saliva natural.

Numerous starch granules were discovered with the microscope in the feces. This excretion was also very acid in its reaction, and of a dark, almost black color.

EIGHTH DAY.

INGESTA.

8 A.M.	Starch	2225	Water	5700
1 P.M.	"	2525	"	10000
5 "	"	3500	"	10000
Total	"	8250	"	25700

EGESTA.

Kidneys.

Whole quantity of urine 20130.87.

Water	19781.62	
Solids	549.25	
Urea		185.33
Uric acid		7.94
Chlorine		4.30
Sulphuric acid		3.09
Phosphoric acid		5.86
Residue		342.73

Intestines.

Whole quantity of feces 900.61.

Water	758.88	
Solids	141.73	
Ether extract		30.13
Alcohol extract		25.37
Water extract		12.60
Insoluble residue		73.63

Skin and Lungs.

Total loss from these channels 14048.52.

At 7 A.M. my pulse was 92, at 2 P.M. 94, and at 10 P.M. 94.—Mean 93.33.

The temperature of the body at the above hours was respectively 98.5°, 99.5°, and 99°.—Mean 99°.

My weight at the end of the twenty-four hours was 224.57 pounds; a loss from the preceding day of .19 pound, or 1330 grains.

The mean heights of the barometer and thermometer were respectively 29.105 inches, and 15.33°.

Violent headache was present during the whole day. The mind was somewhat confused; an almost constant twitching of the left superior eyelid was experienced, and caused me a great deal of annoyance. The oppression of the chest had returned, and was only relieved by frequent, full, and deep inspirations. There were also griping pains in the lower part of the abdomen, attended with the discharge of much flatus. The pyrosis still continued. Palpitation of the heart less violent and frequent. Several boils made their appearance on various parts of the body.

The urine, when tested, as before mentioned, exhibited the same characteristic signs of the presence of sugar as previously. Reaction strongly acid. Starch granules in the feces.

NINTH DAY.

INGESTA.

8 A.M.	Starch . . .	3500	Water . . .	7600
1 P.M.	" . . .	3500	" . . .	9500
5 "	" . . .	4500	" . . .	10500
Total	" . .	11500	" . .	27650

EGESTA.

Kidneys.

Whole quantity of urine 23352.11.

Water	22879.95	
Solids	472.16	
Urea		132.58
Uric acid		9.47
Chlorine		3.01
Sulphuric acid		2.61
Phosphoric acid . . .		5.50
Residue		318.99

Intestines.

Whole quantity of feces 1256.45.

Water	1043.21	
Solids	213.24	
Ether extract		21.36
Alcohol extract		18.51
Water extract		15.74
Insoluble residue		157.63

Skin and Lungs.

Total loss from these channels 13631.44.

At 7 A. M. on this day my pulse was 90, at 2 P. M. 93, and at 10 P. M. 95.—Mean 92.66.

The temperature of the body at these hours was respectively 99.5°, 99.5°, and 100°.—Mean 99.66°.

The weight of the body at the end of the twenty-four hours was 224.70 pounds; an increase of .13 pound, or 910 grains over the previous day.

The mean height of the barometer was 29.252 inches, and of the thermometer 13°.

The symptoms observed on this day did not differ materially from those of the day before. I was obliged, however, from weakness and general indisposition, to go to bed at 8 P. M. Did not sleep well.

The urine was still highly saccharine, and of the same clear brown color as before noticed.

TENTH DAY.

INGESTA.

8 A. M.	Starch	2200	Water	6000
2 P. M.	"	4525	"	11500
5 "	"	3500	"	9000
Total	"	10225	"	26500

EGESTA.

Kidneys.

Whole quantity of urine 22785.

Water	22272.43
Solids	512.57

Urea			121.77
Uric acid			9.36
Chlorine			1.89
Sulphuric acid			2.26
Phosphoric acid			5.31
Residue			340.59

Intestines.

Whole quantity of feces 1250.27.

Water	945.42	
Solids	204.85	
Ether extract		25.63
Alcohol extract		25.80
Water extract		17.43
Insoluble residue		135.49

Skin and Lungs.

Total loss from these channels 12599.73.

My pulse at 7 A.M. was 91, at 2 P.M. 90, and at 10 P.M. 93.—Mean 91.33.

The temperature of the body at the same hours, was respectively 99°, 99.5°, and 99.5°.—Mean 99.33°.

At 3 P.M. I abstracted 1350 grains of blood from the median basilic vein, and, upon analysis, found it to be constituted as follows:—

1000 parts of serum—

Water	920.81	
Solids	79.19	
Albumen		63.45
Extractive		12.35
Soluble salts		2.12
		77.92
Difference		1.27

The whole quantity of inorganic salts in 1000 parts of serum was 2.89.

1000 parts of blood—

Water	796.49	
Solids	203.51	
Fibrin		3.15
Blood-corpuscles		132.60
Albumen		55.96
Extractive		11.25
Soluble salts		1.87
		204.83
Difference		1.32

The whole quantity of inorganic salts in 1000 parts of blood was 2.05. In 1000 parts of defibrinated blood were 2.74 of fat.

The weight of the body at the end of the twenty-four hours was 224.53 pounds; being a loss of .18 pound, or 1260 grains. As, however, 1350 grains of blood were taken from the body, there

was an actual increase of 90 grains, or, more properly, would have been, but for the loss of blood.

The mean height of the barometer was 29.155 inches, and of the thermometer 12.66°.

The general symptoms observed were of the same character as those of the last two days, but more strongly marked.

The urine was highly saccharine, and of the same brown color; resembling Madeira wine.

The immediate effect of the slight abstraction of blood was to relieve the feeling of oppression at the chest; but in an hour it returned with increased violence. The debility was very great.

The experiments with starch were now at an end. Immediately on their termination, I ate a hearty breakfast, but my stomach was in so weak and disordered a condition, that the food was almost instantly rejected. I found that I was obliged to resume my ordinary diet with some degree of caution. After a few days, I became free from all unpleasant symptoms, and rapidly regained my usual good health. It is remarkable, however, that for the first few days after the conclusion of the experiments, I steadily lost weight, so that on the tenth day, I weighed but 223.18 pounds. Sugar was detected in the urine till the morning of the sixth day.

The accompanying table embraces the main results of the foregoing investigations:—

Table VI.

	1st day.	2d day.	3d day.	4th day.	5th day.	6th day.	7th day.	8th day.	9th day.	10th day.	Total.	Mean.
INGESTA.												
Starch	9500	10500	11300	12000	10800	10000	9500	8250	11500	10225	103575	10357.50
Water	24500	26250	28926	29000	27000	25250	24300	25700	27650	26500	265076	26507.60
Total	34000	36750	40226	41000	37800	35250	33800	33950	39150	36725	368651	36865.10
EGESTA.												
Kidneys—												
Whole quantity of urine	14339.51	14970.83	19735.24	20245.10	18275.82	15160.06	15282.25	20130 87	23352.11	22785.00	184276.79	18427.67
Water	13588.69	14327.62	19296.09	19787.10	17885.11	14631.87	14856.45	19781.62	22879 95	22272.43	179106 93	17910.69
Solids	750 82	643.21	439.15	458.00	390.71	528.19	425.80	549.25	472.16	512.57	5169.86	516.98
Urea	421.57	369.15	225.06	204.29	160.47	176.28	157.05	185.33	132.58	121.77	2153.55	215.35
Uric acid	6.34	5.42	5.18	7.53	7.26	8 49	8 36	7.94	9.47	9.36	75.35	7.53
Chlorine	85.26	31 04	14.27	8.41	8.03	6.22	4.74	4.30	3.01	1.89	167.17	16.71
Sulphuric acid	30.45	19.68	12.07	10.55	6.70	4.12	3.81	3.09	2.61	2 26	97.34	9.73
Phosphoric acid	27 18	25.97	26.61	13.29	10 55	5 64	5.70	5.86	5.50	5.31	136.67	13.66
Residue	180.02	183.95	155.96	216.74	197.70	347.84	244.14	342.73	318.99	340.59	2528.66	252.86
Intestines—												
Whole quantity of feces	1041.86	1076.53	925.01	1438.15	1145.90	1097.00	946.17	900.61	1256.45	1250.27	11077.95	1107.80
Water	816.96	858.18	724.47	1013.08	937.68	910.47	750.70	758.88	1043.21	945.42	8862.15	886.21
Solids	224.90	218.35	200.54	425.07	205.22	186.53	195.47	141.73	213.24	204.85	2215.90	221.59
Ether extract	49.72	51.36	45.13	40.26	35 78	29 89	33.76	30.13	21.36	25.63	363.02	36.30
Alcohol extract	50.29	39.12	28.74	29.13	30.65	34.75	34.29	25.37	18.51	25.80	316.65	31.66
Water extract	30 18	24.39	35.41	28.64	20.50	14.65	27.42	12.60	15.74	17.43	226 96	22.69
Insoluble residue	94.71	103.48	91.26	327.01	118 29	107 24	100.00	73.63	157.63	135.49	1309.54	130.95
Skin and Lungs—												
Total loss by these channels	19798.34	21122.64	18585.75	18476.25	18518 28	18782.94	17921.58	14248.52	13631.44	12590.73	173685.97	17368.59
Total egesta	35179.71	37170.00	39246.00	40160.00	37940.00	35040.00	34150.00	35280.00	38240.00	36626.00	369040.71	36904.07
Variation in weight of body	—1179.71	—420.00	+980 00	+840.00	—140.00	+210.00	—350.00	—1330.90	+910.00	+90.00	—3[illegible]9.71	—38.97 8
Pulse	82	84	83.66	83.66	86 33	87 66	89.66	93.33	92.66	91.33	..	87 42
Temperature of body	97.50°	98.16°	98.16°	98.83°	99°	99.16°	98.33°	99°	99.66°	99.33°	..	98 81
Barometer	29.276	29.086	29.213	29 366	29.510	29.426	29.141	29.105	29.252	29.155	..	29.253
Thermometer	—1.66°	3°	—4.66°	—0.66°	1°	9.33°	12.33°	15.33°	13°	12.66°	..	6.03°

A consideration of the foregoing investigations, and comparison of the results with those of the standard series, show that under the use of food consisting only of starch and water, the following effects ensued.

Kidneys.—The whole quantity of urine was lessened, as was also the amount of its solid matter, and that of each constituent (urea, uric acid, chlorine, and sulphuric and phosphoric acids). The residue of solid matter remaining after the deduction of the sum of the above named substances was, however, greatly increased.

The diminution in the quantity of urine eliminated, was partly due to the fact that there was a less amount of fluids ingested than during the preliminary series, and partly, that the food was not of a character to maintain the several solid constituents at their ordinary normal amounts. It was from this latter cause that so great a reduction took place in the quantity of urea, uric acid, chlorine, and sulphuric and phosphoric acids. During the present investigations, these substances must have been entirely derived from the disintegrated tissues of the body; the food containing no matter from which they could have been elaborated.

The increase of solid residue was probably owing to the sugar present, and, perhaps, to some other substance containing a large proportion of carbon. The increased depth of color observed in the urine, supports this latter hypothesis. Recent investigations have almost completely established the fact, that the coloring matter of the urine is a vehicle for the removal of carbon which has not been eliminated by other channels.[1]

The fact that sugar was detected in the urine after a few days' use of the starch, is important physiologically, and must have no little bearing upon the pathology of a disease as yet but little understood.

According to Bernard,[2] sugar in the animal economy has an internal and external origin, the liver being the organ by which it is formed in the system, and the food furnishing that derived from without. This physiologist is, however, of opinion (and he adduces many striking experiments in support of this theory), that normally the sugar taken into the system with the food, and which enters the portal vein, never reaches the general circulation, but is destroyed

[1] Bird. Urinary Deposits, p. 88.

[2] Leçons de Physiologie expérimentale. Cours de semestre d'hivers, 1854, 1855. The reader is referred to this work for Bernard's views in full.

by the liver, and transformed into an emulsive substance, possessing none of the chemical or physical characteristics of sugar. The sugar of the food, therefore, is never normally found as a constituent of the urine. To this rule he makes an exception as regards cases of fasting, and the subsequent ingestion of a large quantity of sugar. Then, he states, absorption from the intestines taking place with increasing energy, a great quantity of sugar is thrown upon the liver, and, being more than it is able to transform, the excess passes into the main circulation, and is found in the urine.

The present investigations, it is seen, are entirely opposed to Bernard's doctrine of the perfect destruction of the alimentary sugar by the liver, as it is not probable the sugar found in my urine could have had any other origin than the food which was transformed into this substance in the intestines, and absorbed as such into the circulation.

In obtaining this result, I am not altogether alone. Von Becker has definitely established the fact, that the amount of sugar in the blood is influenced by the character of the food, and Uhle and Lehmann found it to appear in the urine of rabbits after the injection of a solution containing it into the blood.

I am disposed to regard the appearance of sugar in the urine, ensuing upon the excessive use of amylaceous food, to be due to a deficient relative amount of oxygen in the blood. This hypothesis may be more clearly set forth by recalling the facts, that before assimilation, the starch taken as food is transformed into dextrin, then into glucose or grape sugar, and is chiefly under this form absorbed into the system. The sugar, after its entrance into the blood-vessels (provided a sufficient amount of oxygen be brought into chemical contact with it), is, after undergoing continued metamorphosis, entirely decomposed into carbonic acid and water, and, as such, is eliminated from the pulmonary mucous membrane. A deficiency of oxygen causes a partial interruption of this process, and a portion of the sugar is merely metamorphosed into fat, and under this form remains in the system. A still greater deficiency of oxygen, or, what amounts to the same, a corresponding increase of the quantity of sugar in the blood, would cause a portion of this latter substance entirely to escape metamorphosis, and this portion would make its appearance as a constituent of the urine if augmented beyond a definite amount. In support of this theory are to be adduced the numerous carefully conducted investigations of Dechambre, from which it appears that sugar is constantly to be

met with in the urine of the aged as an effect of deficient hæmatosis. It is well known that the use of feculent food invariably increases the proportion of this substance in diabetic urine.

Intestines.—The quantity of feces was reduced, as was also that of each of its constituents determined.

The decrease in the total amount of feces was due to the facts, that starch is a substance of easy digestibility, and that no indigestible substances were taken into the system.

The reduction in the amounts of ether, alcohol, and water extracts, was also mainly owing to the character of the aliment. As no fat was taken with the food, it would seem that the first of these was present in greater amount than could have been expected, unless we adopt the hypothesis that farinaceous food is converted into fat in the intestines; to which theory the experiments of Boussingault on ducks are directly at variance.

The weight of the body is seen to have declined altogether 9 ~~403~~.71 grains, not counting, in this calculation, the weight of the blood abstracted for analysis. This loss is much less than the drain from the waste of the nitrogenous tissues, and shows that a very considerable amount of new matter must have been deposited within the system. The chemical constitution of starch forbids the idea that this material could have been of a nature to serve for the renovation of the worn-out tissues of the body. It must, on the contrary, have consisted of fat, derived from the metamorphosis of the amylaceous food. The slight loss of weight observed shows, therefore, that the starch was assimilated not only in quantity sufficient for the immediate wants of the system, but also in such an amount as to allow the deposition of fat to such an extent as, within a few grains, to compensate for the total loss through the nitrogenous constituents of the excretions. The actual increase observed in the temperature of the body, and several of the pathological occurrences, also show that there was no deficiency of carbon in the system.

Effect upon the Constitution of the Blood.—The annexed table exhibits the results of the analysis of the blood on the 1st and 10th days of the experiments.

TABLE VII.

1000 parts of serum—	1st day.	10th day.	1000 parts of blood—	1st day.	10th day.
Water	907.34	920.81	Water	779.33	796.49
Solids	92.66	79.19	Solids	220.77	203.51
Albumen	75.02	63.45	Fibrin	1.99	3.15
Extractive . . .	6.18	12.35	Blood-corpuscles .	141.18	132.60
Soluble salts . .	10.72	2.12	Albumen	63.66	55.96
			Extractive . . .	4.84	11.25
Whole quant. inorg. salts	11.98	2.89	Soluble salts	9.31	1.87
			Whole quant. inorg. salts	10.42	2.05
			Fat	1.83	2.74

From this table it is seen that, in the serum, the water was increased in quantity, and the solids proportionally diminished. The albumen and salts were reduced in amount, whilst the extractive was very much increased.

In the whole blood, the proportion of water was likewise increased, and that of the solids lessened. The fibrin, extractive, and fat, were augmented; the blood-corpuscles, albumen, and salts diminished.

Most of these results were to have been anticipated. The most important of them are the increase in the fibrin, extractive, and fat.

So many different views of the value and character of the fibrin of the blood are held by physiologists, that I merely state the fact of its occurrence in this fluid in increased amount after farinaceous diet, without attempting to account for it. Whether fibrin is a substance of the ascending or descending grade of metamorphosis, is as yet far from determination.

The increase in the amount of fat is sufficiently accounted for by the character of the food, and might have been anticipated, if the theory given explanatory of the cause of the presence of sugar in the urine be regarded as correct. The diminished amount of fat in the blood after the albuminous diet, and its increase after an amylaceous one, show that the proportion of this substance in the circulating fluid is subject to variation with the character of the ingesta; a circumstance with which the experiments of Boussingault[1] are at variance.

The increase in the proportion of the extractive, was probably due to some carbonaceous substance present in augmented quantity.

[1] Op. cit., p. 281, et seq.

Upon the whole, if further evidence of the incapability of starch to sustain for any length of time health or life in the human subject were wanting, the present investigations would appear to furnish it. The value of starch is, however, very great, for, notwithstanding the derangement of the health, both physical and mental, produced by strict adherence to a diet of this substance, it is perceived that but slight loss of weight occurred. This latter fact, resulting as it did from the deposition of fat, is not to be regarded as an entirely normal result. Nevertheless, it is a most valuable indication that farinaceous food fulfils the condition of supplying a sufficiency of carbon to the system.

III.

GUM.

The chemical constitution of gum differs from that of starch, only in containing two additional atoms of both hydrogen and oxygen. It is never found as a component part of the bodies of animals, and of the vegetable substances ordinarily used as food by man, few, if any, contain it. It is, however, occasionally employed in the sick-room, from an idea, formerly very prevalent and not yet entirely extinct, that it possesses great nutritive power, and is sometimes met with as an ingredient of certain sweet-meats.

Notwithstanding that it is exceedingly soluble in water, the recorded experiments of several physiologists tend to show, that gum is possessed of little or no nutritive value, or capability of supporting respiration, owing to its almost complete indigestibility. Thus, Boussingault[1] fed a duck with fifty grammes of gum Arabic, and found forty-six in the excrements, and Frerichs, Blondlot, and Lehmann,[2] found that neither the saliva nor gastric juice exercised any digestive effect upon this substance.

With the object of contributing to the more complete elucidation of the subject, the following investigations were instituted. My original intention was to have continued them, if possible, ten days, as in the former two series; but, owing to the debility and great

[1] Mémoires de Chimie agricole et de Physiologie, p. 232.

[2] Lehmann's Physiological Chemistry, vol. ii. p. 386.

derangement of health produced, I was obliged, very much to my regret, to discontinue them at the end of the fourth day.

Pure gum Arabic was the article used during these investigations. It was ingested dissolved in water (the proportion of this liquid entering into its composition having been previously ascertained). The figures relating to the gum refer to the dry substance, and those indicating the quantity of water, to the whole amount of this liquid taken into the stomach uncombined, and with the gum. The water was distilled, or rain-water. No other food was taken.

The conditions of physical and mental exercise, sleep, &c., were as far as possible the same as in the previous series. I was unable, however, to adhere as rigidly to the standard system as I desired. The deviations are noticed in the proper places. Twenty-five days elapsed between the termination of the starch series of investigations and the commencement of the present. At this latter time my health appeared to be very good. At the end of the twenty-four hours immediately preceding my weight was 225.33 pounds.

FIRST DAY.

INGESTA.

8 A.M.	Gum	. . . 2300	Water . . .	9000
1 P.M.	"	. . . 3000	" . .	10000
5 "	"	. . . 3000	" . .	10000
Total	"	. . . 8300	" . .	29000

EGESTA.

Kidneys.

Whole quantity of urine 20728.61.

Water	20157.03	
Solids	571.58	
Urea		330.15
Uric acid		7.45
Chlorine		46.28
Sulphuric acid		21.57
Phosphoric acid . . .		24.13
Residue		142.

Intestines.

Whole quantity of feces 8529.14.

Water	3284.34
Solids	5244.80

Ether extract	31.55
Alcohol extract . . .	30.27
Water extract	5030.36
Insoluble residue . . .	152.62

Skin and Lungs.

Total loss through these channels 12422.94.

My pulse at 7 A.M. was 80, at 2 P.M. 84, and at 10 P.M. 89.—Mean 84.33.

At the same hours, the temperature of the body was respectively 98.5°, 98°, and 97.5°.—Mean 98°.

At 3 P.M. I took 1359.31 grains of blood from the median basilic vein. This, upon analysis, was found to be constituted as follows:—

1000 parts of serum—

Water	907.43
Solids	92.57
Albumen . . .	77.36
Extractive . . .	5.15
Soluble salts . . .	9.22
	91.73
Difference	.84

The whole quantity of inorganic salts in 1000 parts of serum was 11.01.

1000 parts of blood—

Water	778.04
Solids	221.96
Fibrin	2.05
Blood-corpuscles .	138.22
Albumen . . .	66.32
Extractive . . .	4.08
Soluble salts . . .	7.96
	218.63
Difference . . .	3.33

The whole quantity of inorganic salts in 1000 parts of blood was 10.49. 1000 parts of defibrinated blood contained 2.13 of fat.

The weight of the body at the end of the twenty-four hours was 224.57 pounds; being a loss of .82 pound, or 5740 grains; of which 1359.31 are to be ascribed to the blood abstracted for analysis, leaving a balance of 4380.69 grains as the actual loss from the excretions.

The mean height of the barometer on this day was 28.324 inches, and of the thermometer 31.33°.

About the middle of this day I felt quite hungry. After eating the gum at 5 P.M., this feeling subsided, but returned again in the course of the evening. I had severe colicky pains in the lower part of the abdomen after eating the second meal of gum. Had two evacuations from the intestinal canal; one at 9 P.M., and one at 6½ A.M. The feces of both were hard, of a dark brown color, and of a very strong acid reaction.

SECOND DAY.

INGESTA.

8 A.M.	Gum	. . . 2150	Water . . .	9300
1 P.M.	"	. . . 2100	" . .	10000
5 "	"	. . . 3000	" . .	10050
Total	"	. . . 7250	" . .	29350

EGESTA.

Kidneys.

Whole quantity of urine 21385.97.

Water	20934.74	
Solids	451.23	
Urea		301.24
Uric acid		8.20
Chlorine		21.15
Sulphuric acid		12.05
Phosphoric acid . . .		13.35
Residue		95.24

Intestines.

Whole quantity of feces 9350.28.

Water	3975.09	
Solids	5375.19	
Ether extract		17.43
Alcohol extract . . .		12.84
Water extract		5297.62
Insoluble residue . . .		47.20

Skin and Lungs.

Total loss through these channels 11883.75.

At 7 A.M. on this day my pulse was 88, at 2 P.M. 88, and at 10 P.M. 94.—Mean 90.

At the corresponding hours the temperature of the body was respectively 97°, 97.5°, and 97.5°.—Mean 97.33°.

At the termination of the twenty-four hours my weight was 223.65; a loss of .86 pound, or 6020 grains.

The mean height of the barometer was 28.706 inches, and of the thermometer 8°.

The feeling of hunger was very strong on this day, and I experienced a good deal of debility. Both the hunger and weakness became less a short time after eating, but they soon returned. The pains in the abdomen still continued. They became more severe

after eating. Two evacuations of the bowels occurred, one at $2\frac{1}{2}$ P.M., the other at 7 P.M. They were both hard, and were of a much lighter color than on the previous day. Reaction strongly acid. At night my sleep was disturbed by unpleasant dreams, and I awoke in the morning with severe headache and high fever.

The saliva was scanty, and of a slight acid reaction to litmus paper.

THIRD DAY.

INGESTA.

8 A.M.	Gum . . .	2000	Water . .	10000
1 P.M.	" . . .	2150	" . . .	9890
5 "	" . . .	3150	" . .	10230
Total	" . . .	7300	" . .	30120

EGESTA.

Kidneys.

Whole quantity of urine 23721.50.

Water	23334.71	
Solids	386.79	
Urea		282.64
Uric acid		9.27
Chlorine		6.33
Sulphuric acid		6.97
Phosphoric acid		7.09
Residue		74.49

Intestines.

Whole quantity of feces 9783.56.

Water	3152.09	
Solids	6631.47	
Ether extract		10.72
Alcohol extract		9.55
Water extract		6581.40
Insoluble residue		29.80

Skin and Lungs.

Total loss from these channels 10704.94.

At 7 A.M. my pulse was 104, at 2 P.M. 112, and at 10 P.M. 110.—Mean 108.66.

At the same hours the temperature of the body was respectively 99.5°, 101°, and 101°.—Mean 100.50°.

At the end of the twenty-four hours my weight was 222.68;

showing a loss from the preceding day of .97 pound, equivalent to 6790 grains.

The mean height of the barometer was 29.264 inches, and of the thermometer 19°.

The debility and hunger were extreme on this day. There was also considerable febrile excitement, attended with heat and dryness of the skin, and headache. I was too much indisposed to read any, and the physical exercise was likewise reduced. In the afternoon, I was obliged to lie down, and at that time slept about one hour.

Three operations from the bowels occurred, one at 12 M., one at 4½ P.M., and one at 7½ P.M. The feces were very solid, and of a light clay color. I was very much annoyed by the abdominal pains. At night I was restless, and slept but little. In the morning, awoke feverish, and unrefreshed.

FOURTH DAY.

INGESTA.

8 A.M.	Gum	2000	Water	9000
1 P.M.	"	2400	"	9500
5 "	"	2500	"	11500
Total	"	6900	"	30000

EGESTA.

Kidneys.

Whole quantity of urine 20516.31.

Water	20163.88	
Solids	352.43	
Urea		274.50
Uric acid		9.35
Chlorine		3.20
Sulphuric acid		3.90
Phosphoric acid		4.55
Residue		56.93

Intestines.

Whole quantity of feces 10964.73.

Water	3529.71	
Solids	7435.02	
Ether extract		10.14
Alcohol extract		8.30
Water extract		7390.10
Insoluble residue		26.48

Skin and Lungs.

Total loss by these channels 12656.45.

At 7 A.M. on this day my pulse was 102, at 2 P.M. 99, and at 10 P.M. 108.—Mean 103.

At the corresponding hours, the temperature of the body was respectively 97.5°, 98°, and 97.5°.—Mean 97.66°.

Perceiving that I should not be able to continue the investigations after this day, I abstracted at 3 P.M., 1272.51 grains of blood from the median basilic vein. The analysis yielded the following results:—

1000 parts of serum—

Water	912.84
Solids	87.16
Albumen	72.40
Extractive	8.23
Soluble salts	5.11
	85.74
Difference	1.42

The whole quantity of inorganic salts in 1000 parts of serum was 6.89.

1000 parts of blood—

Water	784.35
Solids	215.65
Fibrin	2.71
Blood-corpuscles	135.64
Albumen	62.20
Extractive	7.39
Soluble salts	4.01
	211.95
Difference	3.70

The whole quantity of inorganic salts in 1000 parts of blood was 6.37. 1000 parts of defibrinated blood contained 1.80 of fat.

The weight of the body, at the end of the twenty-four hours, was 221.63 pounds; a loss, therefore, of 1.05 pound, or 7350 grains; of which, 1272.51 are accounted for by the blood abstracted, so that there remain 6077.49 grains as the loss by the excretions.

The mean heights of the barometer and thermometer were respectively 29.369 inches, and 8°.

The hunger, debility, and febrile excitement were very great on this day; but not more so than on the previous day. The pains in the abdomen were severe, and lasted nearly the whole period of twenty-four hours. There was also some tenderness of the abdomen on pressure. Eating the gum failed now to relieve, even for a short time, the sensation of hunger. Four evacuations occurred from the intestinal canal; one at 11 A.M., one at 3 P.M., one at 9 P.M., and the other at the regular hour. All were very solid, and of a light clay color. It required a good deal of straining to eject the feces. I omitted all study on this day, and took but a trifling amount of physical exercise. The greater part of the afternoon was passed in bed. At night, I did not sleep at all well.

Fearful of inducing disease if I persevered with the experiments, and also what was perhaps a more powerful inducement, unable longer to refrain from other food, I discontinued them at the end of this day.

About 4 P. M. of the fifth day from the commencement I felt great weight and pain in the rectum, but was unable to pass anything at stool. I therefore took an enema of warm water, and in a few minutes ejected a large quantity of hard fecal matter streaked with blood. The water extract of this amounted to 3352.45 grains. No other examination of the excrement was made.

I felt very much indisposed for several days after the conclusion of the researches, but by care, and prudence in diet, no very untoward result ensued.

The results of this series are contained in the accompanying table:—

TABLE VIII.

	1st day.	2d day.	3d day.	4th day.	Total.	Mean.
INGESTA.						
Gum	8300	7250	7300	6900	29750	7437.50
Water	29000	29350	30120	30000	118470	29617.50
Total	37300	36600	37420	36900	148220	37055.00
EGESTA.						
Kidneys—						
Whole quantity urine	20728.61	21385.97	23721.50	20516.31	86152.39	21538.09
Water	20157.03	20934.74	23334.71	20163.88	84390.36	21097.59
Solids	571.58	451.23	386.79	352.43	1762.03	440.50
Urea	330.15	301.24	282.64	274.50	1188.53	297.13
Uric acids	7.45	8.20	9.27	9.35	35.27	8.81
Chlorine	46.28	21.15	6.33	3.20	76.86	19.21
Sulphuric acid	21.57	12.05	6.97	3.90	44.49	11.12
Phosphoric acid	24.13	13.35	7.09	4.55	49.12	12.28
Residue	142.00	95.24	74.49	56.93	288.66	67.16
Intestines—						
Whole quantity feces	8529.14	9350.28	9783.56	10964.73	38627.73	9656.93
Water	3284.34	3975.09	3152.09	3529.71	13941.23	3485.30
Solids	5244.80	5375.19	6631.47	7435.02	24686.50	6171.62
Ether extract	31.55	17.43	10.72	10.14	79.84	19.96
Alcohol extract	30.27	12.84	9.55	8.30	60.96	15.24
Water extract	5030.36	5297.62	6581.40	7390.10	24299.48	6074.87
Insoluble residue	152.62	47.20	29.80	26.48	255.10	63.71
Skin and Lungs—						
Total loss by these channels	12422.94	11883.75	10704.94	11496.45	47668.08	11917.02
Total egesta	41880.59	42620.00	44210.00	42977.49	171688.08	42922.02
Variation in weight	—4380.69	—6020.00	—6790.00	—6077.49	—23268.18	—5817.04
Pulse	84.33	90	108.66	103	...	96.49
Temperature of body	98°	97.33°	100.50°	97.66°	...	98.37°
Barometer	28.324	28.706	29.264	29.369	...	28.915
Thermometer	31.33°	8°	19°	8°	...	16.58°

In considering these investigations, it is seen that the following effects ensued:—

Kidneys.—The whole quantity of urine and the proportion of water were increased; the solids and amounts of each constituent were very much reduced.

Intestines.—The whole quantity of feces, the water, solids, and water extract were enormously increased over the normal average and the means of either of the other series of researches. The ether and alcohol extracts were decreased in quantity.

Skin and Lungs.—The loss from these sources was less than under either the albumen or starch series, and was probably also below the normal extent.

The loss of weight in the body was very great.

The pulse was increased in frequency, as was also the temperature of the body.

The following table shows the alterations induced in the composition of the blood:—

TABLE IX.

1000 parts of serum—	1st day.	4th day.	1000 parts of blood—	1st day.	4th day.
Water	907.43	912.84	Water	778.04	784.35
Solids	92.57	87.16	Solids	221.96	215.65
Albumen	77.36	72.46	Fibrin	2.05	2.71
Extractive	5.15	8.23	Blood-corpuscles	138.22	135.64
Soluble salts	9.22	5.11	Albumen	66.32	62.20
			Extractive	4.08	7.39
Inorganic salts	11.01	6.89	Inorganic salts	10.40	6.37
			Fat	2.13	1.86

From this table it appears that in the serum the proportion of water was augmented, and that of the solids was diminished, and that the albumen and salts were reduced in amount, and the extractive increased. In the whole blood, the same effects ensued with the addition that there was a slight increase in the amount of fibrin, and a decrease in the blood-corpuscles and fat.

It is evident from these researches that but little, if any, of the gum taken into the stomach was absorbed into the circulation. In all, 29,750 grains of gum were ingested. The water extract of the feces, which consisted almost entirely of gum, amounted during the four days of the investigations to 24,299.48 grains. To this sum should of course be added the water extract obtained the day after

the conclusion of the experiments (3352.45 grains), making a total of 27,651.93 grains, which, with the exception of very small quantities of other matters, consisted entirely of gum. A balance of 2098.07 grains remains, but it is probable that a considerable portion, if not the whole of this, was subsequently passed from the bowels, as hard lumps continued to be discharged from this channel for several days.

The great loss of weight (nearly 3.33 pounds) is not surprising after a knowledge of the above facts. Water was always taken in such quantities as desired, or of course the decrease of weight would have been much greater. The fever, hot skin, &c., were indicative of irritation and debility.

If we admit the non-absorption of the gum, the solid constituents of the urine must have been entirely derived from the effete tissues of the body. The amounts of each are therefore probably such as would have been excreted had no food been taken into the stomach. The carbonic acid of the expired air could have had no other source than the oxidation of the fat of the body, which also furnished a portion of the aqueous vapor expired.

The alterations in the proportions of the several constituents of the blood are also doubtless such as would have taken place under inanition. The increase observed in the quantity of extractive and fibrin is important, but may have been accidental.

From these researches I conclude that gum, so far from having any value as an alimentary substance, is positively injurious, owing to the fact of its clogging the intestines, and thus proving a cause of irritation. As an article of food for the sick, its use should be especially condemned.

In order to facilitate comparison of the results of the several foregoing series of experiments, the following table of the means of each course is subjoined:—

TABLE X.

	Ordinary diet.	Albumen.	Starch.	Gum.
INGESTA.				
Solid	...	8343.20	10357.50	7437.50
Water	...	24598.80	26507.60	29617.50
Total	...	32942.00	36865.10	37055.00
EGESTA.				
Kidneys—				
Whole quantity of urine .	20898.71	17738.50	18427.67	21538.09
Water	19801.13	16919.62	17910.69	21097.59
Solids	1097.58	988.87	516.98	440.50
Urea	694.63	715.19	215.35	297.13
Uric acid	11.67	20.76	7.53	8.81
Chlorine	138.13	8.86	16.71	19.21
Sulphuric acid . . .	45.18	16 92	9.73	11.12
Phosphoric acid . .	55.85	22.04	13.66	12.28
Residue	194.37	215.19	252.86	67.16
Intestines—				
Whole quantity of feces .	2293.92	3558.36	1107.80	9656.93
Water	1673.99	2968.35	886.21	3485.30
Solids	619.92	590.02	221.59	6171.62
Ether extract . . .	90.60	13.65	36.30	19.96
Alcohol extract . . .	95.56	114.58	31.65	15.24
Water extract . . .	129.55	102.35	22.69	6074.87
Insoluble residue . .	303.18	358.94	130.95	63.71
Skin and Lungs—				
Total loss by these channels	...	14475.65	17348.54	11917.02
Total egesta	...	35841.42	36879.07	42922.02
Variation in weight[1] . .	...	—28994.20	~~—4607.00~~ [illegible]	—5817.04
Pulse	84.23	91.83	87.42	96.49
Temperature of body . .	97.83°	97.39°	98.81°	98.37°
Barometer	...	29.139	29.253	28.915
Thermometer	...	40.41°	6.03°	16.58°

Résumé.

From the preceding investigations, I think the following conclusions (several of which, however, are already well established) fairly deducible, and applicable to the human subject:—

1. That albumen may be assimilated into the system in such quantity as to furnish a sufficiency of both nitrogen and carbon to the organism.

2. That under the use of an exclusively albuminous diet the nitrogenous constituents of the urine are increased over the ordi-

[1] Owing to neglect to ascertain the weight of the body before commencing the preliminary series of experiments, the mean variation cannot be given.

nary average amounts, though not in proportion to the quantity of albumen absorbed into the circulation.

3. That either some other means than the urine exist for the elimination of nitrogen from the system, or the excess (over two-thirds) is retained in the organism, even when the body is rapidly decreasing in weight.

4. That the continued use of albumen as an article of food increases the proportion of this substance (and of fibrin) in the blood, and in a short time causes it to appear in the urine.

5. That whilst pure albumen cannot be regarded as of itself adequate to supply the several wants of the system, there is no reason why, when associated with suitable inorganic matters, it should not support both life and health.

6. That starch can be assimilated by the absorbents in more than sufficient quantity to sustain the respiratory function.

7. That under its use the nitrogenous constituents of the urine are very much reduced in amount, even below what would probably occur during inanition, and, that although starch is not capable of nourishing the tissues, it is yet serviceable, aside from its heat producing power, in retarding their destructive metamorphosis.

8. That the continued use of highly amylaceous food causes the appearance of sugar in the urine.

9. That under the use of such aliments the nitrogenous constituents of the blood are diminished, and the carbonaceous increased.

10. That gum is altogether incapable of assimilation, and therefore possesses no calorifacient or nutritive power whatever, but is, on the contrary, a source of irritation to the digestive organs.

11. That in consequence of the above fact, the solids of the urine during the immediately preceding researches, were entirely derived from the waste of the tissues of the body, and the carbon exhaled by the lungs from the consumption of its fat.

12. That gum, when exclusively used as food, from the irritation it causes in the intestinal canal, and the fact of its non-assimilation, induces more constitutional disturbance than either starch or albumen, and that under a similar condition starch is more productive of ill consequences than albumen.

The investigations which it was the special object of this memoir to detail, are now concluded, and are respectfully submitted to the Association.

In an essay of this character, whose chief aim is to add to the sum of knowledge, the labors of others could at most receive but a slight notice, and must of necessity frequently be passed over without even a word of recognition. Yet no one appreciates more highly than myself the self-devotion and constant striving to enlarge the bounds of science, which animate so many physiologists of the present day, and which have already yielded such brilliant results. Had I, however, attempted to do justice to even a tithe of their contributions, I should have converted this memoir into a treatise, and might have lost sight of all originality in my efforts to make a successful compilation. With what success I have prosecuted these inquiries is not for me to determine. I cannot, however, think them valueless, for, if they only excite others throughout our land to investigate in living beings the operations of nature, they will still be beneficial to the cause of that science which constitutes the basis of all medical knowledge. From the united labors of those who seek by original investigations to build up a positive science, where there is yet so much darkness and uncertainty, what may we not expect? May we not confidently look forward to the perfect enlightenment of our minds in regard to the most obscure of the vital processes? Though we may often be led astray by experiments conducted without due care, and with insufficient knowledge, they yet afford the only means by which we can successfully work out the sublime problems which the Great Creator of all has proposed for our solution.